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TO

MARTYN PAINE, A.M., M.D., LL.D. AND PROF.

NEW YORK, U.S.

THIS VOLUME IS DEDICATED,

AS A MARK OF RESPECT FOR HIS VARIED AND EXTENSIVE

ACQUIREMENTS, AND FOR HIS NUMEROUS AND

ABLE CONTRIBUTIONS TO THE MEDICAL

LITERATURE OF THE

NEW WORLD.

PREFACE.

THE science of chemistry, by the aid of which we ascertain the composition of bodies in general, together with the various modifications which this composition may undergo, affords two very different methods of procedure, each of which possesses certain advantages. It is, however, more especially in a Treatise on Chemistry, and while describing the actual condition of chemical science, that an author feels himself called upon to pronounce in favour of one or the other. A few words of explanation, therefore, are here necessary.

The *first method* of procedure, the most simple and classic, consists in investigating the elementary principles of bodies, and their various combinations. It is thus that chemists have described oxygen, hydrogen, sulphur, the different metals, etc., and the combinations resulting from their reciprocal action. This method has been exclusively adopted by the authors of the most extensive and valuable treatises on the science of chemistry; nor have they failed to carry out the same plan in relation to organic chemistry. But as in this last we have no longer to deal with simple bodies, the nature of immediate principles becomes now the object of research. The method of extracting these principles, and of obtaining them in a state of purity, is therefore treated of; the effects of various chemical reagents, and their reciprocal actions, are duly investigated, as well as the organic compounds of which these principles form an integral portion, and the part which they perform. It is thus that in all works on chemistry, a portion is devoted to the subject of organic chemistry, which is treated of in the manner just described; it is, moreover, upon this same plan, that MM. Robin and Verdeil have lately published an excellent *Treatise on Anatomical and Physiological Chemistry*, in its special application to the study of the immediate principles of organized bodies.

The *second method* of procedure is, it is true, less simple, we might almost say less logical; but it is, at the same time, more useful to one who is already initiated in the science of chemistry. In adopting this method, we investigate the composition of different substances as they are presented to us in nature. We endeavour to ascertain how their various constituent elements are associated, how they react upon each other, of what variations they are susceptible, and how the composition of such substances may be altered thereby.

It is thus that, in inorganic chemistry, the composition of rocks, earths, and minerals has been studied; while by the application of chemistry to the vegetable kingdom, the composition of the different parts of plants, of their juices, fruits, etc., has been, in a great measure, elucidated.

Lastly, it is thus that, in animal chemistry, the composition of each organic tissue, and of the fluids, (such, for instance, as the *blood*, the *milk*, the *urine*, etc.,) is ascertained; and the different modifications investigated which each may undergo in health and disease.

It cannot be denied that this method of procedure, more especially as regards animal chemistry, is far more useful to the physiologist and physician than the mere study of immediate principles.

This synthetical method of procedure is better adapted to physiological and pathological researches; it becomes more readily and certainly identified with them, and is not at variance with the ordinary logical method by which those researches are, for the most part, carried out. Many treatises on chemistry have been published upon this plan. The first, the most complete, and the most justly esteemed, was that of Simon. Some years afterwards, M. Lheritier published, in France, a *Treatise on Pathological Chemistry*, which did not meet with the success it merited. More recently, M. Lehmann, in Germany, published a similar work, which did not, however, supersede that of Simon.

Since the publication of these treatises, pathological chemistry, both in France and elsewhere, has made great advances. Numerous researches have been made and published, relative to the different pathological changes which the solids and fluids of the human body may undergo. It is, therefore, with the intention of collecting and arranging in a convenient form, all that is at present known, that we have decided on publishing a *Treatise on Pathological Chemistry in its Application to Practical Medicine.*

We cannot here impress too strongly upon the mind of the reader the fact, that we have in no wise attempted to write a work on chemistry, but rather to make an application of chemical facts to medicine properly so called, and especially to pathological anatomy. We shall now briefly state the views by which we have been guided in the composition of this treatise, and the plan which we have adopted.

The work is divided into six chapters.

The *first* is very short; it is devoted to the study of the two fluids which contribute to the formation of the blood: the *Lymph* and the *Chyle.*

The *second*, the longest and most complete, is appropriated to an investigation of the *Blood.* In its composition, we have adopted the following method of procedure, from which we have never deviated, when examining a fluid, a healthy tissue, or a pathological formation. We begin, then, by stating the plan upon which the analysis of the blood is to be conducted. We then enumerate the different immediate principles which it contains, and then proceed to their individual consideration, stating, at the same time, the modifications which each may undergo, whether in health or in disease. We then consider, synthetically, the composition of the blood in health, and the variations which are compatible with this condition. We then pass on to the pathological changes of which it is susceptible. These we trace, not only in the chief classes of disease, but likewise in each affection specially considered, and we conclude by a statement of the practical consequences to which a knowledge of these modifications of the blood may lead.

The *third chapter* is appropriated to an investigation of the *Fluids secreted by the conglomerate glands.* We examine, in succession, the *saliva*, the *bile*, the *pancreatic juice*, the *urine*, the *spermatic fluid*, the *milk*, and the *tears;* treating of each, in a manner similar to that previously adopted with regard to the blood.

The *fourth chapter* is devoted to an examination of the products of *Secretion, whether solid, liquid, or gaseous*, furnished by the organic membranes. The *mucous membranes* and their *mucus*, both in health and in disease, here afford a subject for consideration. We then pass on to examine the special modifications to which the secretions derived from the mucous membrane of the digestive organs, of the respiratory apparatus, of the genito-urinary passages, and, lastly, of the nasal passages, are liable. The second portion of this chapter contains an account of the products furnished by the *serous membranes*, while the third is devoted to the subject of the *cutaneous secretions.*

The *fifth chapter* contains an exposure of the very scanty results which science possesses, relative to the normal composition of the *Tissues*, and to the pathological changes of which they are susceptible. This chapter is rather, in fact, a summary of the *desiderata* of science in this respect, than a catalogue of results already acquired.

Lastly, the *sixth chapter* is devoted to the consideration of *newly formed pathological products.* It is thus that we have successively treated of the chemico-microscopic history of *pus*, *tubercle*, and *cancer*.

During the whole course of our labours, we have borne in mind, that the work which we now offer is especially addressed to the physician, and that, as such, it should afford him a simple, concise, but, at the same time, complete account of the actual condition of science, relative to the chemical composition of those fluids, tissues, and organs, which he must constantly be under the necessity of examining, in his endeavours to contribute to the advancement of science.

October 1*st,* 1853.

TRANSLATOR'S PREFACE.

If we admit that the science of medicine is entitled to its elevated rank, not merely on account of the benefits it confers, but from the high and rational basis on which it is founded, we must likewise admit, that by a knowledge of this basis alone can we secure for it such a position in the hierarchy of science, as is its due. Public opinion is too often divided, and public estimation too often diminished in these matters, simply because the fixed principles and axioms, on which the science really rests, are so often doubted and denied. These doubts and denials arise from various sources, which it is needless here to mention; but it would seem clear, that if we can accomplish their removal upon rational principles, or, in other words, if we can prove by an analysis of our human composition, that the materials of which it consists and the changes to which it is liable are amenable to certain laws over which we possess a certain measure of control, we then remove much of that conjectural portion of its essence which prejudice and ignorance lay hold of, to turn to their own account.

We all know what modern chemistry has done towards the advancement of science in general, but we do not all know what Physiological and Pathological Chemistry have done towards the advancement of medical science in particular. What is their object? what is their business? To shew us what we are made of,—To tell us in what the principles of life and disease consist,—To describe, both by analysis and synthesis, the nature of those elements and compounds of which the human machine is made up, and by which its movements and support are regulated; and to shew us, above all, the nature of those conditions in which deviation from health consists.

Without such knowledge, what rational groundwork has our science to stand on? How can it resist the charges so often made against it? How can quackery and distrust do otherwise than prevail? The former, in fact, ignores all this; catching a hold of the passions and therefore of the public, it appeals to feelings and so-called facts, rather than to theories or principles; and thus, instead of furnishing us with aught like a rational groundwork to rest on, whether as regards premises, inferences, or conclusions, it satisfies itself with the number of cases it can enlist and the number of cures it has performed.

All this, however, is nothing new; we are aware of the ravages which quackery has committed, but we are not aware of the ways and means by which they may be removed. These alone can be furnished by an intimate knowledge of the structure of the human system, in both its healthy and its diseased states. We may blame our neighbours, the French and Germans, for their minuteness and prolixity in conveying a knowledge of the latter, and hold cheap their labours at the bedside of the patient; but there can be little doubt, that, by means of such labours, they have afforded an insight into our science, or rather into our art, for which the true physician, of whatever country, must feel himself under a debt of gratitude.

Now, to obtain this insight, Pathological Chemistry has, among other branches of our profession, been brought into requisition, and here we come at once to what may be called a modern science. For in proportion as new types of civilization have produced new types of disease, must the aggregate of those laws which regulate the latter gather itself up into a new science. So long as Chemistry limited its investigations to the objects of the external world, and confined itself to the elements and compounds *around* us, rather than *within* us, so long was it comparatively useless as a curative agent. But now that it has taken so different a direction, and become so powerful an instrument in shewing us how the elements of nature and human nature are assimilated;

when it has shewn us how those elements may become modified by the application or removal of different agencies and influences; and when, above all, it can throw such light on the diagnosis of disease, it of course becomes a new instrument in the hands of the physician, and renders that path clear which was once so confused.

Were there no other motive for the translation of the present work, it would be sufficient to make us think that it may prove acceptable; but when to this is added the known fact of our neighbours having devoted such enlarged and enlightened attention to the subject, and, above all, the high celebrity of its authors' names,—names which for the last twenty years have been associated with many important researches relative to the Pathological Chemistry of the human body,—still more do we feel assured that our labours will not have been entirely in vain.

We deem it right here to state, that for convenience sake, the French measurements have, in most instances, been retained; such as, the gramme (15 grains); the metre (39 inches); the millimetre ($\frac{1}{25}$th to $\frac{1}{26}$th of an inch). We have had the less scruple in so doing, from the conviction that these measurements are now tolerably familiar to the majority of the profession.

S. T. SPEER.

ETON HOUSE, CHELTENHAM,
Oct. 25th, 1856.

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PATHOLOGICAL CHEMISTRY.

CHAPTER I.

OF THE FLUIDS WHICH CONTRIBUTE TO THE FORMATION OF THE BLOOD.

ARTICLE I.

OF THE LYMPH.

THE lymph is the fluid conveyed by the lymphatic vessels. Being extremely difficult to procure, in quantity sufficient for the purposes of analysis, our information respecting it is very limited. We shall, nevertheless, attempt its description in accordance with the few documents which we possess.

The lymph is a thick, viscid liquid, of a yellowish, or greyish yellow colour, with an occasional reddish tint. Owing to the fibrin which it contains, it coagulates, on being isolated, almost immediately. Upon the admixture of lymph and chyle in the thoracic duct, depends the power of coagulation which this latter fluid possesses.

Examined under the microscope, the lymph presents a few scattered globules. They are smooth, spherical, of a yellowish tinge, smaller than the blood globules, and vary in diameter from 0.004 to 0.005 of a millimètre.*

The coagulum formed by the lymph, on being exposed to the air, assumes a reddish hue. The best method of procuring this fluid is to place an animal upon a very small allowance of food, and then to seek for the liquid contained in the thoracic duct, which, by this process, will be found entirely free from chyle.

---

* *A millimètre is the* 0.03937 *of an inch.*

The coagulability of the chyle was long known to be in inverse ratio to the amount of aliment absorbed. This admits of an easy explanation, since, as we have said, its coagulability depends on admixture with the lymph. The more abundant, therefore, the chyle, the less easily will it coagulate.

We know of but three analyses of human lymph, which we subjoin:

Analysis of Gmelin.

Water	961.0
Solid matters	39.0
Fibrin	2.5
Albumen	27.5
Chloride of sodium, phosphate of soda, and potash	2.1
Extractive matter, and lactate of soda	6.9

Analysis, by Marchand and Colberg, of lymph taken from a wound in a man's ankle.

Water	969.26
Solid matters	30.74
Fibrin	5.20
Albumen	4.34
Extractive matter	3.12
Liquid fat	2.64
Chlorides of potassium and sodium, alkaline sulphates and carbonates, sulphate and phosphate of lime, peroxide of iron	15.44

The following analysis of lymph drawn from the thoracic duct of a man who had died of ramollissement of the brain, and who had taken nothing but a small quantity of water for thirty hours before death, was made by Lheritier:

Water	924.36
Solid matters	75.64
Fibrin	3.20
Fat	5.10
Albumen	60.02
Salts	8.25

We have quoted these analyses chiefly with the view of shewing how little we know of the subject. They afford simply an approximation to the probable composition of the lymph; and we do not hesitate to say that the physiology and pathology of this liquid have yet to be investigated, and their history written. We speak, moreover, of a history based upon positive chemical and physical data, and not upon a variety of absurd hypotheses.

ARTICLE II.

OF THE CHYLE.

Of this fluid we likewise possess but few analyses, especially as regards man. Experiments, however, made upon animals, have enabled us to study it with care, and to ascertain the part which it plays in the process of digestion. The chyle is that liquid which circulates in the lymphatic vessels of the intestines, *i.e.*, the lacteals. During digestion alone, do these vessels contain chyle; at other times they are merely filled with lymph, as in other parts of the body.

In order to obtain the chyle in its greatest purity, the animal must be destroyed at the moment when the digestive process has attained its maximum of intensity. In man, chance alone can afford an opportunity of procuring and analyzing this fluid. It is usually taken from the thoracic duct, where it is always found mixed with a certain quantity of lymph; and this it is which vitiates the majority of results afforded by analysis, and prevents us from ascertaining the exact composition of pure chyle.

Pure chyle is an opaque, white, lactescent fluid: it is not coagulable, and when found to possess this property, it must be attributed to the admixture of a certain quantity of lymph. Microscopic examination shews it to be composed of a transparent fluid, in which are suspended different species of globules or particles, of which the following are the most important:

1. Spherical particles of exceedingly small dimensions, resembling fine dust. Their diameter cannot be ascertained.

2. Larger globules, resulting from an agglomeration of the elementary granules. They are round, and clearly defined, almost transparent, and vary in diameter from 0.006 to 0.01 of a millimètre. They are granular; and it is even possible to

discern the manner in which their agglomeration takes place. As both the molecular granules and the composite globules are dissolved by ether, it is evident that they are composed of fatty matter.

3. Lastly, we sometimes find lymph globules, as described in the preceding chapter.

The above microscopic appearances may be readily accounted for when we call to mind that the chyle is chiefly composed of fatty matters that have been reduced to a state of extreme division by the pancreatic juice. The presence of chyle may, therefore, be considered as subordinate to the existence of fatty matters in the ingested aliment, *i.e.* to their increase or decrease.

Chemical Analysis of the Chyle in Man.[*]

Water	902.37
Solid matters	97.63
Fibrin	3.70
Fat	36.01
Albumen	35.16
Extractive matters soluble in water and alcohol	3.32
Extractive matter soluble in water only	12.33
Salts	7.11

We do not consider it necessary to allude here to the experiments made by the same author, as well as by Tiedemann, Gmelin, and Nasse, upon the chyle of the horse, the dog, and the cat, etc. The elements are almost identical in each, viz., a liquid containing a large proportion of water, and about an equal amount of albumen and fatty matter.

It would be out of place to discuss here the part played by the chyle in the animal economy, or to examine its formation, its origin, and the changes which it undergoes when it enters the blood. This is a purely physiological question, with which we have nothing here to do.

In a pathological point of view, then, little has been done; and the difficulty of procuring this fluid will always prove an obstacle to those who would attempt its analysis.

---

[*] This analysis of chyle, taken from the thoracic duct of a man who had suffered the punishment of death by suspension, is due to Rees, and is the only one we possess.

CHAPTER II.

OF THE BLOOD.

SECT. I.

ITS HISTORY.

The history of those numerous works of which the blood has been the subject from the remote periods of antiquity up to the present day, comprises three distinct phases or epochs. The first, which includes a long succession of ages, is a history of the various hypotheses which have been formed relative to the composition of the blood, rather than one of positive research. Yet, these hypotheses, which have undergone almost as many variations as there have been different systems of medicine, once enjoyed considerable favour: they, in fact, constituted the basis of the humoral system in its divers aspects; and albeit now sunk in oblivion, we do not conceive it right that they should be passed over in silence, and shall therefore endeavour to describe them succinctly.

The second phase in the history of the alterations of this fluid, includes the first positive researches of which it was made the subject. These researches comprise various qualitative analyses, which have afforded numerous and interesting documents relative to pathology and physiological chemistry.

The third phase, of which the history extends but a few years back, comprises an exposition of the quantitative analyses of the principal elements of the blood. It is only since the commencement of this period, that our knowledge of the alterations of the blood has proved capable of advancing physiology and pathology, and of throwing light upon various pathogenetic questions of importance.

First Period.

A history of the opinions which have successively held sway in the scientific world, relative to the blood and its alterations, would be that of humoralism in general; for the part attributed to the blood by the ancients is almost invariably so entwined with that which they imagined the other fluids to perform, that it is difficult to separate them.

Before Hippocrates, it seems doubtful whether even an hypothesis had been framed relative to the alterations of the blood. At this epoch first arose a belief in the modifications which it might possibly undergo; proofs of which may be found in his writings. Of these, the following are the principal:*

1. "At the age of seven, adynamia and discoloration of "countenance, with humid respiration when walking, and a "desire to eat earth, indicate corruption of the blood." (*Prenotions of Cos,* transl. by Littré, vol. v., p. 677.)

2. "If the weather during summer and autumn be dry "and windy, this condition is especially obnoxious to bilious "individuals: in fact, it has a too astringent effect upon them. "..... The watery portion of the bile being dissipated, the "thicker and more acrid residuum remains. It is so likewise "with the blood; and hence the origin of disease in bilious "subjects." (*Of Airs, Waters, and Places,* § 10, transl. Littré, v. ii., p. 51.)

3. "Ardent fever takes place when the veins, being dried "up in the summer season, attract acrid and bilious humours "to themselves." (*On Regimen in Acute Diseases,* Syden. Edit., vol. i., p. 313.)

4. "When pains precede, and there are influxes of black "bile and of acrid humours, and when, by their pungency, the "internal parts are pained; and the veins, being pinched and "dried, become distended, and, getting inflamed, attract the "humours running into the parts, whence the blood becomes "vitiated," etc., etc. (*Syden. Edit.,* vol. i., p. 316.)

5. "Owing to this defluxion being of a cold and viscid

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* Bourgade, *Thèse sur les altérations du sang.*

"nature, it becomes enfarcted, obstructing the passage of the "respiration and of the blood, coagulates the surrounding "blood, and renders it motionless and stationary; it being "naturally cold, and disposed to obstructions." (Op. cit., vol. i., p. 316.)

6. "In many there was a superabundance of that humour, "which gives rise to hæmorrhage." (*Of Epidemics*, book i., Littré's Transl., vol. ii., p. 645.)

But, while admitting the theory respecting the four fundamental humours existing in the human body, Hippocrates himself attaches to it but a moderate degree of importance; nor does he by any means appear to regard this theory as the basis of medicine generally. His successors, however, attribute more and more importance to the blood, the humours, and their alterations.

Plato also regarded the alterations of the humours as the proximate cause of the great majority of diseases. He supposed that the fleshy portions of the body, when brought into contact with certain visionary triangular atoms, gave rise to various humours, which infected and deteriorated the blood, altering its colour, and rendering it acrid and bitter. What was pure blood, being thus converted into bile, phlegm, or serum.

According to Erasistratus, fever depended upon plethora, *i.e.*, upon an excess of blood, which, when it unduly filled and distended the veins, rushed into the arteries, and ejected the spiritual essence, or *pneuma*, which these latter vessels were supposed to contain. This combination of the blood and the pneuma, set the body on fire and deranged all its functions.

Asclepiades attributed pain to some vitiation of the coarser particles of the blood, which becoming too viscid to circulate freely (for he believed in a species of spontaneous circulatory motion in the pores), stopped, and over-distended the parts. In his opinion, dropsy was due to the pores becoming too numerous and too relaxed, thus converting the blood into water.

According to Aretæus of Cappadocia, the blood and the pneuma of phthisical individuals becoming too subtle, it was necessary to prescribe a diet and medicines capable of thickening them; such, for example, as milk, starch, fecula. He believed also in the transformation of blood into bile; of which he held that there were several species.

Celsus likewise believed in the alterations of the blood. He recommended that, previous to venesection, great attention should be paid to the nature of the disease; whether it arose from an excess or a deficiency of this fluid, or from its being vitiated in any way. He moreover forbad bleeding, when the blood was deficient or healthy; but recommended it to be employed when diseased or in excess. "*Utrum superans an* " *deficiens materia læserit. Nam si materia vel deest, vel* " *integra est illud alienum est; at si copia seu male habet,* " *vel corrupta est nullo modo melius succurritur.*"

Celsus likewise advises us to notice the quality of the blood at its exit from the vein. If thick and black it is bad, and the bleeding must be continued; if clear and red it is healthy, and the flow should at once be arrested. If the blood, when first drawn, be black and viscid, and become clear and ruddy during the flow, it is a sign that enough has been drawn,—the remainder is healthy: "*Sanguis qui crassus aut niger initio* " *fluxerat et rubere et pellucere cœpit, satis materiæ de-* " *tractum est, atque quod superest sincerum est.*"

Galen propounded a complete theory respecting the formation of the blood, and of the part which it plays in disease. According to his views, the quantity and quality of this fluid are especially influenced by aliment. The chyle being elaborated in the stomach, passes from thence into the mesenteric veins and liver: in this organ it becomes converted into blood. Its depuration, according to Galen, likewise takes place here: the gall bladder attracts that portion which is soft and yellow, the spleen that which is thick and muddy; while the kidney eliminates the watery portion, the excess of which would render the blood unfit for the purposes of nutrition. He believed, moreover, that the different humours—the phlegm, the bile, and the atrabile—were derived from the blood.

Galen asserts the blood to be composed of four elements—fire, water, air, and earth; from which it derives its properties

—viz., heat and moisture. The bile, on the contrary, is hot and dry; the atrabile dry and cold; the phlegm cold and moist.

The causes of disease are attributable, according to the physician of Pergamos, to a vitiation of the humours, which consists of plethora, or increase of quantity, on the one hand, and of cacochymia, or perversion of quality, on the other. This latter constitutes what he designates, putridity.

The blood is more particularly that fluid, the modifications of which consist of a superabundance or plethora. It is in virtue of this excess that it is enabled to flow towards organs which usually contain none, and thus to produce inflammation. An excess in point of quantity is rare with respect to the other humours, albeit it may occasionally occur: it is more especially by their deterioration or corruption that they alter and vitiate the blood. Such, in fact, is the origin of the cachexiæ. Fever is engendered when the mass of blood becomes heated, agitated, and inflames the whole body. "*Vocant id malum corporis febrem.*" When this is the case, the pulse, the use of which is to cool the blood and to free it from the excrementitious particles by which it is infected, becomes stronger and fuller; and if this be not sufficient for the purpose, it becomes still more frequent. When, on the contrary, the heat diminishes, and the blood no longer requires to be cooled, the pulse becomes slower and smaller. General putrescence of the blood produces fever,—or rather, putrid fever. There are several kinds of fevers, each of which corresponds to a special putrescence of this fluid.

Lastly, Galen recommends blood-letting, in all cases where it may be deemed necessary to diminish the mass of the blood, or to carry off noxious materials. "*Quando copiosior sit justo aut pravus.*"

From this rapid summary we see, that the doctrine respecting the alterations of which the vital fluid is susceptible, finds a place in the medical literature of the earliest ages. It is, however, founded solely on hypothesis; and to hypothesis alone did the ancients recur, in order to explain the phenomena observed. Nevertheless, these hypotheses—or rather, the theory of Galen—were admitted, with but little opposition, for fourteen centuries; during which period the different schools, among which we may reckon the Arabian, did nought but comment upon his doctrines.

In the seventeenth century, several great scientific discoveries gave a new and powerful impulsion to hæmatology. The circulation of the blood was discovered by Harvey; the thoracic duct and the lymphatic circulation by Pecquet; while science in general, under the influence of Galileo, Bacon, Descartes, etc., was by degrees brought back into a more natural channel—that of direct experiment. At this period, moreover, chemistry, although still based upon views, many of which were erroneous and hypothetical, began to furnish results susceptible of application to human physiology and pathology.

Humoralism, then, continued to exist in the scientific world, its explanation alone having undergone a change; the study of the modifications of heat, cold, dryness, and humidity, being replaced by an inquiry into the action of acids, alkalies, salts, ferments, etc.

Sylvius de la Boë was the first to attempt a classification, or rather, a theory of the alterations of the blood, in accordance with the chemical views of the epoch. He considers these alterations as divisible into four distinct classes, depending upon changes occurring—1. In its objective qualities; 2. In its quantity; 3. In its circulation; 4. In its fluidity.

1. *Of the objective qualities of the blood.*—Under this head, De la Boë studies its colour, smell, taste, and temperature; he notices, moreover, the buffy coat as being the result of inflammatory action.

2. *Of the quantity of the blood.*—He admits that it may be increased (in plethora) or diminished.

3. *Of the flow of blood.*—The flow of blood in the vessels may be accelerated, slackened, or arrested. Its prolonged stagnation produces inflammation; from whence, at a subsequent period, results its fermentation and transformation into pus.

4. *Of the fluidity of the blood.*—When an excess of acid or acrid material is formed in the blood, its viscidity increases; this produces stagnation, obstruction, inflammation, and fermentation. The fluidity of the blood is, on the other hand, increased in malignant fevers and in the plague. Food, drink, poisons, etc., are so many causes which, although acting in different ways, tend to produce these results. Sylvius de la Boë here notices the effects produced by the injection of alkaline salts into the vessels, which he found to augment the fluidity of the blood, whilst acids, similarly employed, coagulated it.

Such is the theory of Sylvius; founded, indeed, upon the observation of facts, and upon experiments made on animals; while, for an explanation of the phenomena observed, he trusts almost exclusively to hypothesis.

Amid, however, these hypothetical views, we find certain facts noticed, which have now attained the rank of accepted truths in the hierarchy of science. Such, for instance, as the stagnation of the capillary circulation, in certain morbid conditions of the blood, and under the influence of cold; the dissolution of the blood, under the influence of alkalies and of certain poisons; a want of alkalinity in the blood, and the possibility of its transformation into pus.

The theories of Sylvius have found advocates and supporters in Vieussens, Bellini, and Ramazzini.

The discovery of the blood globules by Leeuwenhoeck, imparted a new direction to the study of this fluid and its changes. The investigation, however, became more generalized; physics and mechanics being appealed to, in conjunction with chemistry, in order to explain the alterations of the blood and the part which they played in disease.

Boerhaave was the first to introduce mechanical principles, as bearing upon the subject of the blood and its modifications. He admitted three important changes to which it was liable; and these he held to be derived from the food.

1 and 2. An acid acrimony, or glutinous viscidity of the blood, is produced by the abuse of farinaceous aliment, or of

raw fermenting fruits, which acquire within the body, the same qualities which moist heat would produce in them under ordinary circumstances. This acid humour and viscidity, originating in the digestive organs, renders the blood pale and glutinous, and produces obstruction and concretions in the vessels.

3. Alkaline acrimony of the blood is due to another species of diet. An abuse of animal food engenders this morbific matter, which passes into the blood and produces its putrid dissolution.

According to Boerhaave, the blood may undergo certain other changes. Thus, it may contain acrid, aromatic, saline, purulent, and ichorous matters, etc. These matters, formed in the blood, irritate the heart and accelerate its contractions. It follows, therefore, that this fluid, being driven with violence into the vessels, which react vigorously upon it, becomes compressed, and an increased amount of friction between the globules is thus produced. This gives rise to an abnormal elevation of temperature, and an evaporation of the watery particles, whence results an inflammatory viscidity, capable of obstructing, distending, and even rupturing the capillary vessels, and thus producing inflammation, suppuration, and gangrene.

According to the theory of Boerhaave, plethora is due to the rarifaction caused by the rapidity of the circulation of the blood, and to the heat which this engenders: it may even, says he, cause obstruction. The same results may likewise be produced by a want of circulation, and by a dispersion of the watery particles of the blood, under the influence of sweat, salivation, diuresis, diarrhœa, etc.

These different alterations of the blood have the effect of either dissolving or rendering it more viscid. The latter change is by far the most frequent. Dissolution occurs only in connexion with the predominance of an alkaline matter. To viscidity or thickening was generally attributed obstruction of the vessels—a theory which long held extensive sway.

But Boerhaave goes still further, and admits a special alteration of the blood globules. "Obstruction," says he, "arises "from the limited calibre of the vessels, from the amount of "fluid which has to traverse them, and from a combination of "the two." (*Aph.* 108.)

The mass of the blood may be increased in a twofold manner: 1. When the spherical shape of the globule becomes so altered as to present a larger surface to the aperture of the vessel; 2. When several particles, previously separated, unite into one small mass. (*Aph.* 115.) In either case, obstruction is the result: the stagnant portion of the blood is agitated and forced into the capillaries by the remainder of this fluid; the watery parts escape, while the more solid portion which is left distends the vessels, and produces inflammation. (*Aph.* 382.) If in such a case we bleed, and receive the blood in a large vessel, its surface presents, on cooling, a thick hard white coating. (*Aph.* 384.)

Should the obstruction persist, the distended capillaries burst; their contents are extravasated, dissolved, and finally undergo decomposition; moreover, the solid particles, broken down and subdivided, become mingled with the fluids, and form an homogenous liquid, which is white, viscid, and greasy; this is denominated pus. (387.) If this pus be reabsorbed, it mixes with and poisons the blood, disturbs the functions of the viscera, and thus produces a variety of dangerous maladies. (*Aph.* 406.)

To sum up then, Boerhaave, we find, asserts that the blood may undergo five distinct modifications, which are as follows:

1. Admixture with certain morbific matters, originating either in the digestive organs, in an inflamed part (pus), or introduced from without.
2. Escape of the watery portion of the blood.
3. A change in the blood globules, or their agglomeration into small masses.
4. Transformation into pus.
5. The production of a white coating on its surface (the buffy coat).

In 1733, Hales published his *Treatise on Hæmostatics.*

We shall here give an epitome of the theories therein propounded.

He supposes the blood to be endowed with certain peculiar properties, such as attraction, repulsion, vibration, elasticity, etc.; and he further holds, that health results from an equilibrium existing between these different properties, whilst its derangement produces disease.

He explains the different stages of fever, by the increased or diminished friction of the blood globules. An increased vibration of the globules augments their friction and temperature, and thus produces fever. Fermented liquors have a similar effect, as also that which he calls tartar.

Hales considers the red sediment in the urine, so often noticed at the period when fever is about to terminate, to be a consequence of the exit of tartar from the blood. He likewise regards gout as due to the presence of a particular kind of tartar in that fluid.

He admits also a variation in the proportions of the globules, and a thin, watery condition of the blood in dropsies; the chilliness observed in these cases, arises from the fact that the blood no longer contains a sufficient number of globules to maintain the normal temperature of the body.

According to this author, the same results follow a considerable loss of blood, because the loss is always tardily repaired.

Hales does not appear to have rejected direct experiment. He injected hot water into the arteries of living animals, and ascertained that death occurred in every case where the blood became too diluted. When the experiment was not pushed so far, the body of the animal became swollen and dropsical.

Sauvages has made some curious experiments upon the buffy coat of inflammatory blood, and notices its existence in acute rheumatism and pleurisy. He proved its existence, moreover, after death, in the ventricles of the heart, and in the large vessels. Sauvages compares this buffy coat to the albumen of the serum when coagulated by heat, and admits that, in the human body, during disease, there is produced a degree of heat equivalent to that which suffices to harden the white of an egg, or the serum of the blood.

Sauvages endeavours also to explain why it is that 75° of heat (centigrade) are necessary in order to coagulate albumen out of the body; while in disease a temperature not exceeding 40° is sufficient to produce the same effect. These explanations are, however, purely hypothetical; and he himself allows that the cause of the buffy coat was then unknown. Sauvages describes, moreover, a liquefaction of the blood as occurring in inflammatory and malignant fevers, and seems inclined to believe in the transformation of blood into pus.

Huxham, in his *Essay on Fevers*, investigates the condition of the blood. He believes it may undergo three distinct modifications:

1. It becomes thick and viscid. This result is due to the increased number of the globules, and to their amalgamation one with the other. To explain this, Huxham adopts a theory very similar to that of Boerhaave. The formation of the buffy coat is, he believes, owing to the elevation of temperature which occurs in fever.

2. There is another modification of the blood, due to the paucity and separation of the globules, and to the watery condition of the serum. From it results an analogous condition of the secretions which are derived from the blood, together with a stagnation of this fluid in the capillaries, and that peculiar condition which occurs in malignant fevers.

3. The last alteration of which the blood is susceptible consists, according to Huxham, in its dissolution and decomposition: hence the origin of scurvy. To this author is due a knowledge of the fact, that an admixture of alkaline salts with the blood increases its fluidity; and he applies it to the various forms of decomposition of which he conceives the blood to be liable, as in scurvy, petechial, putrid, and malignant fevers, small-pox, purulent absorption, etc.

Are there not then among these ideas of Huxham, certain positive facts which are even admitted at the present day? the error of the celebrated English physician being simply that of endeavouring to explain them, by having recourse to a series of hypotheses which we do not consider it necessary here to reproduce.

About the year 1750, De Haen published the results of numerous experiments made upon the fibrin and upon the buffy coat; but while pointing out the relationship existing between the two, he hesitates to admit their identity of structure and composition. De Haen, however, investigated the nature of the buffy coat with much care, and pointed out the circumstances under which it may be produced, together with the modifying influences to which it was exposed.

Some years later, Pringle pointed out the decomposition and dissolution of the blood, as occurring in certain diseases, such as malignant fever, hospital fever, petechial fevers, etc.; while Lind also, carefully described the condition of the blood in scurvy. According to this author, the alteration of the blood in these diseases, consists in a tendency to decomposition and dissolution, which is due to the want of a chyle capable of correcting the acrimony of the juices, and to a considerable deficiency on the part of the respiratory process. Basing his practice upon this theory, Lind considers the administration of acids in scurvy to be of secondary importance, and lays most stress upon good diet and the use of fresh vegetables.

To these writers succeeded Bordeu, who endeavoured to unravel the labyrinth of hypotheses which then prevailed, touching the alterations of the blood. He regarded these alterations as dependent upon the excess of certain humours, constituting the cachexiæ; and he attributed the phenomena which they present, to the excessive predominance of one or other of these humours in the blood.

According to Bordeu, there are twelve cachexiæ: 1. The bilious; 2. The aqueous; 3. The milky; 4. The urinous; 5. The splenic; 6. The seminal; 7. The adipose. These are all due to a predominance of bile, water, or urine in the blood. 8. The mucous cachexia; 9. The stercoral; 10. The sanguineous. This last he considers as due either to an agitation of the blood, which causes its exit from the vessels, and thus produces hæmorrhage, or to a mere excess of blood, constituting simple plethora. 11. The purulent cachexia; 12. The gangrenous cachexia.

In spite of the pretensions of Bordeu to a nearer approach to the truth than his predecessors, it is impossible not to recognize the hypothetical nature of his views in general.

Bordeu was one of the last partisans of that humoralism which rather presupposed than proved the alterations of the blood. We come therefore now, to the second period, or that which may be conscientiously designated as the "*chemical epoch*," comprising the first forty years of the present century.

Second Period.

Towards the close of the eighteenth century, the science of chemistry, owing to the labours of Scheele, Guyton-Morveau, Berthollet, Lavoisier, was for the first time applied to the investigation of organic matter; an attempt was made to ascertain the nature of compound bodies, and of the ultimate constituents entering into the composition of the organism; and with this object in view, the study of the solids and fluids of the human body was undertaken. Fourcroy was the first, and perhaps the most illustrious, of those chemists who commenced this study, which, since his time, has been uninterruptedly carried out with progressively increasing success. To name all who have contributed to this department of science, would be to designate all the chemical celebrities of the commencement of the present century. We may therefore confine ourselves to those who have rendered especial service to the study of the blood and its composition: Berzelius, Thenard, Prévost, Dumas, Denis, Lecanu, Boudet, Orfila, Barruel, etc.

Of these authors, the majority have almost exclusively confined themselves to purely chemical researches. They treat of the composition of the blood; they point out the distinctive characteristics of each component element; they establish the differences which exist between albumen and fibrin; and lastly, they discover the hæmatosin, fatty matters, etc.

We have now, indeed, taken a great step in advance; and but for these researches, which prepare the way for those of a more exclusively medical stamp, and which characterize the third period, this latter could have had no existence. Was it not, in fact, essential, before weighing such and such a body, to know its nature, its properties, and its composition? Such was the boon bequeathed to science by those great men whose names we have just recorded.

Third Period.

The third period is that in which we now live, and to which it is our boast to belong. To a certain extent, it might not inaptly be termed the *medico-chemical* period. For what, we might ask, is the object of those eminent men who are at the head of that movement to which we wish to attach the term period? Is it not to discover, through the medium of positive chemical data, the truth that lies hidden amid the humoral hypotheses of the ancients, rather than to reconstruct, as has been asserted, a modern rational humoralism; in other words, to establish the real value of the alterations of the blood in disease?

But to attain this object, qualitative analyses of the blood no longer sufficed: a knowledge of the exact quantity of the various component parts of this fluid could alone conduce to such a result.

In a physiological point of view, it is to MM. Prévost and Dumas that we are indebted, for having first ascertained the mean composition of the blood in the human species. Although based upon comparatively few experiments, their researches have nevertheless afforded results which approximate closely to the truth.

To these writers succeeded MM. Denis and Lecanu. The analyses made by the latter, as described in his inaugural thesis, threw additional light on the composition of the blood, and tended still further to attract attention to this department of science. But it is to MM. Andral and Gavarret that we are especially indebted, for the first quantitative analyses made in a large number of cases, and for having determined the primary laws which appear to regulate the alterations of the blood. As we shall frequently have occasion to allude to these admirable researches, we do not consider it necessary to dwell upon them at present. Further investigations, in a similar direction, failed not to appear; and we may perhaps be permitted to say here, that our own labours, so favourably regarded by the Institute of France, have thrown some light on the history of the blood, and have enabled us to establish certain new laws concerning it.

Partial researches relative to the blood have appeared in considerable numbers, since the work of MM. Andral and Gavarret; but as they lay stress chiefly upon details, we shall speak of them in their proper place.

We conceive it right, however, to allude especially to the labours of the Germans; for in France we have not sufficiently acknowledged the numerous valuable analyses of the blood, due to MM. Simon, Lehmann, Nasse, Scherer, and others.

The chemical history of the blood, which we shall now undertake, will consist simply of an exposition of the varied researches made during this third epoch, in France and elsewhere. These we shall consider in the following order:

a. The methods employed for the analysis of the blood;

b. The physico-chemical results of such analysis;

c. The study of the variations to which each constituent of the blood is liable;

d. The composition of the blood in health;

e. The composition of the blood in disease.

SECTION II.

OF THE COMPOSITION OF THE BLOOD, AND OF THE METHODS ADOPTED FOR ITS ANALYSIS.

The blood, according to the most recent researches, holds in suspension or solution a large number of chemical principles: it contains almost all the elements found in the different parts of the organism.

These chemical principles or elements are the following:

1. *Water.*

2. A substance held in suspension—the *globules*, which are themselves composed of an albuminous material and of *hæmatosine.* This last contains the *iron* which is known to exist in the blood.

3. A substance, *sui generis*, which possesses the property of coagulation, when the blood which contains it, is removed from the vessels: this is the fibrin. It is still uncertain whether this substance exists in solution, or is suspended in the form of globules. The latter view appears most probable.

4. The *albumen*, properly so called.

5. Certain *extractive matters*, the nature of which is not as yet accurately determined: these comprise, amongst others, the *colouring matter of the serum*, *osmazome*, etc.

6. Certain fatty matters, viz., *seroline*, *cholesterine*, *oleic* and *margaric* acids, combined with *soda* in a state of saponification. The existence of a *volatile fatty acid* is problematical.

7. *Chloride of sodium* in considerable quantity, and in about equal proportion to the fibrin.

8. Free *soda.*

9. Soluble salts, especially the *sulphates*, *phosphates*, and *carbonates of soda and potash*, etc.

10. Insoluble salts, the product of the different operations to which the blood has been subjected in order to extract its salts, and of the reaction of the inorganic constituents upon one another. These salts are, the *phosphate of lime*, and a very small proportion of *phosphate of magnesia*; possibly a trace of *silica;* and a notable proportion of *iron*, derived from the incineration of the globules.

Our primary object, then, is to isolate and weigh these different substances, as far as is possible, in order to institute a comparison between them in health and disease. This we have endeavoured to do by adopting the following process, the result of numerous preliminary experiments.

The procedure we have adopted consists of three series of operations, which we shall now describe in succession.

First Series of Operations.

This is intended to ascertain: 1. The density of the blood and of the serum; 2. The weight of the fibrine, of the globules, and of the solid matters of the serum, taken in the aggregate. The process is founded upon a principle, similar to that which served as the basis of the plan long since proposed by M. Dumas. It presupposes that all the water contained in the blood forms part of the serum. While admitting the principle, however, we have not applied it in an exactly similar manner.

The following is the process we adopt:

The individual whose blood we wish to analyze, is bled to the amount of about 375 grammes (℥xi. ʒv). The first portion is received in a graduated glass vessel, capable of holding about 125 cubic centimetres*: it is then whipped up with an osier wand; and the fibrin thus obtained is washed, dried, and weighed.

The blood, thus deprived of its fibrin, is set aside for a subsequent series of operations.

That which escapes from the vein after the withdrawal of this first portion, is likewise received into a vessel capable of containing from 250 to 300 cubic centimetres†, and then allowed to stand. The blood coagulates, and as soon as this takes place thoroughly, the serum is carefully strained off into another vessel; as for the coagulum, after having noted its physical characteristics, it may be thrown aside.

A. The defibrinized blood is now weighed, at a given temperature, in a vessel of the density of crystal. A comparison is then drawn between the weight thus obtained and that of an equal bulk of distilled water; and we thus, by a simple calculation, which it is not necessary here to mention, ascertain the exact weight of the 125 cubic centimetres of blood, that have been beaten, in order to separate the fibrin, and, as a consequence, the weight of this same fibrin, as contained in 1000 grammes

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* About 50 cubic inches.

† From about 100 to 120 cubic inches.

(32¼ oz.) of blood. This operation being terminated, a certain quantity of the defibrinized blood is taken, weighed, dried, and then weighed again; and we thus ascertain the amount of water which it contains. To understand this more clearly, let us, for example sake, take an arbitrary number or numbers, which we shall employ afterwards, in order to obtain the weight of the globules: 100 grammes (3⅛ oz.) of defibrinized blood afford 20 parts of solid matter and 80 of water. These 20 parts, thus dried, are calcined, with a view to obtain the inorganic matters: to this subject we shall shortly revert.

B. *The serum.* After having determined the density of the serum, we now take a given quantity of this fluid, which is weighed, dried, and again weighed; the mean difference being the weight of the water: 100 grammes (1500 grs.), for instance, of fluid serum giving 10 grammes (150 grs.) of solid matter, and 90 grammes (1350 grs.) of water. These processes being achieved, we possess the necessary calculations for ascertaining the weight of the globules, and of the solid matters of the serum, contained in 100 grammes of defibrinized blood; and as all the water of this defibrinized blood is due to the serum, we make the following calculation:

$$80 : x :: 90 : 10, \text{ or } x = \frac{80 \times 90}{90} = 8 \text{ gr. } 8.$$

This number, 8.8, represents the sum total of the solid matters of the serum contained in 100 grammes of defibrinized blood; and on subtracting it from 20, which represents the weight of this blood when dried, we obtain 11.2, which stands for the weight of the globules; and on referring our calculation to the standard of 1000, we obtain the following result:

1000 grammes (31¼ oz.) of blood contain—

	Grammes.		Oz.
Water	800	=	25
Globules	112	=	3½
Solid matters of the serum . .	88	=	2¾

The weight of the fibrin has already been ascertained by the first process, and is now to be added.

Such is the first series of operations; for the second, we employ the dried serum; and for the third, blood that has been defibrinized and calcined.

Second Series of Operations.

These have for their object, to ascertain the weight of the extractive and fatty matters. The following is the process employed. The serum having been carefully dried in a stove, and finely pulverized, is repeatedly washed with boiling water, in order to remove all soluble materials. These consist, on the one hand, of extractive matters, such as osmazome, the colouring matter of the serum, etc., and on the other, of free salts which exist in a state of solution in the serum.

The serum, thus treated with water, is again dried and weighed; the loss of weight observed since it was first weighed, indicating the actual amount of those matters just mentioned as having been removed by the water. The product of the second desiccation is now treated with boiling alcohol until thoroughly exhausted. The insoluble residuum consists of pure albumen, the weight of which may be ascertained, when dry. As for the boiling alcohol, it holds in solution all the fatty matters, which may be separated by the process of M. Boudet, and consist of seroline, cholesterine and saponified fat.

Third Series of Operations.

These are intended to furnish the weight of the iron, and of the different inorganic principles, contained in the blood; we must here remark, that these principles do not all exist, either in a free state, or dissolved in the serum, but constitute an integral part, at least in certain proportion, of the albumen, fibrin and globules. This series of operations is entirely due to M. Edmund Becquerel.

The inorganic matters in question are now to be removed from the defibrinized blood already dried. This is first burnt in a platinum crucible at a moderate heat; it yields, as residue, a light charcoal, which is to be pulverized and then calcined at a dull red heat, in a porcelain crucible; it burns slowly, and in about an hour its combustion will be nearly completed. This part of the process presents very considerable difficulty: if the heat be not sufficiently intense, the charcoal will not burn; if too much so, the greater portion of the chloride of sodium, which exists to a considerable extent in the blood, is volatilized and lost; either extreme must be avoided as far as possible.

But whatever precautions be taken, it is almost impossible to prevent the volatilization of a certain quantity of this salt, and hence the proportion of chloride of sodium, as given in the analysis of the blood, usually falls below the mark. The process however, having been always carried out in the same manner, and by the same experimenter, we may suppose, without much fear of being mistaken, that the amount of chloride, thus volatilized, is about the same in every case, and that thus the relative proportions remain nearly identical. It is however necessary to be forewarned, respecting this almost inevitable chance of error.

The charcoal of the blood having now been burnt, there almost always remains a small quantity of carbon, the weight of which must be subtracted in the following manner. Let us suppose, for instance, that the calcined mass gives a residuum weighing 15 grains; of this, 3 grains are to be taken and treated with boiling hydrochloric acid. This dissolves all the saline matters, with the exception of the silica which exists in exceedingly minute quantity in the blood, and leaves behind the carbon, if any remain.

The remaining 12 grains should afford the other inorganic elements. To obtain these, the residuum is washed with distilled water, which dissolves the greater portion, then filtered, and afterwards calcined at a red heat. The small proportion of carbon which remains, and of which the amount was ascertained by the previous weighing, is burnt during this process, and there is left, as a consequence of this twofold operation, a soluble and an insoluble portion, of which the former weighs about 10¼ grains, and the latter, 1⅔ grains.

The soluble residuum contains a large proportion of chlorides (that of sodium preponderating), together with a certain amount of saline matters, such as free soda, carbonates and sulphates of soda and potash, and phosphate of soda. All that can be done here, is to separate and weigh on one side the chlorides, and on the other the soluble salts just mentioned; the saline mass obtained by the previous process being far too small to permit of our isolating its component elements. Doubtless such a separation would be desirable; but with the quantity of blood taken from one patient, it is impossible to obtain a greater amount of saline matter, if we wish at the same time to separate all the other organic elements. We are far from declaring such an analysis to be impossible; but we simply wish it to be understood, that it can only be made by employing the entire amount of blood drawn, for the analysis of the salts alone; while by these means even, but a minute quantity can be obtained; for the most copious bloodlettings seldom exceed 16 ounces, the incineration of which seldom affords more than 60 grains of saline matters.

Returning now to the soluble portion, we treat the solution containing the chlorides with nitrate of silver; and then collect, wash, dry, and weigh the insoluble chloride of silver, from which we deduce, with ease, the weight of the chloride of sodium, by taking for granted that this salt constitutes the entire amount of the chlorides; which is not far from the truth.

On subtracting the weight of the chlorides from the soluble portion, we obtain the weight of the other salts, the free soda, the sulphates, carbonates, etc.

We have now left an insoluble residuum, amounting to about 1⅔ grains; it contains phosphates (chiefly phosphate of lime), and peroxide of iron. It is to be treated with boiling acetic acid, which dissolves the phosphates. The residue consists of peroxide of iron alone, the amount of which is to be ascertained by weighing. We have often asked ourselves the question, whether this peroxide of iron existed as such in the blood, or as free iron. This, however, it appears impossible to decide, and therefore, basing our opinion upon that of chemists in general, we suppose it to exist in the latter condition; and thus, by a very simple calculation, we deduce the amount of iron contained in the blood. It is probable, moreover, that the iron merely becomes oxidized during the series of operations to which the inorganic mass is subjected, in order to isolate its different principles.

SECTION III.

OF THE PHYSICAL AND CHEMICAL RESULTS OF THE ANALYSIS OF THE BLOOD.

Before treating of the physiological and pathological consequences derived from the analysis of the blood, we shall consider certain general results which have been deduced, with rigorous exactness, from experiments performed with as much minuteness and precision, as though elementary analysis had been the object in view. These results may be referred to four headings, which we shall now examine in succession.

ARTICLE I.

ON THE AFFINITY FOR WATER OF THOSE PROXIMATE PRINCIPLES, THE SUSPENSION OR SOLUTION OF WHICH IN WATER, CONSTITUTES THE BLOOD.

Whatever process be employed for analyzing the blood, it is absolutely essential that one or other of its albuminous ingredients be dried carefully apart. Their great affinity for water on the one hand, and their rapid decomposition when exposed to a somewhat elevated temperature on the other, renders this operation by no means easy. It is, nevertheless, indispensable to obtain as perfect a desiccation as possible, without which, nothing but inaccuracy can be expected in the calculations necessary to reconcile with the figure 1000, those different elementary principles, the sum total of which constitutes the blood. It is more especially towards the close of the operation, that the last portion of water is with difficulty driven off, and that it becomes necessary often to leave the albuminous matters for ten, twelve, or fifteen hours in the drying apparatus, in order to be certain that, without undergoing decomposition, they no longer lose aught of their appreciable weight, and consequently contain no water.

The remark just made is the more important, inasmuch as, towards the close of the operation, the albuminous matters no longer alter in appearance, and their decrease of weight is barely perceptible from hour to hour. It may well be conceived what care and attention are necessary to attain the object in view, without leaving in the desiccated mass a few drops of water, capable of materially altering the results of our calculations.

We have ascertained from numerous experiments, that to desiccate about 100 grammes (3 oz., 3 drachms), whether of defibrinized blood, of serum, or of clot, it is necessary: 1. That it be exposed to the continuous action of heat, for at least forty-eight hours; 2. That the temperature be not less than 80 degrees (centigrade); 3. That the albuminous matter should detach itself almost spontaneously from the capsule, and fall to powder without any perceptible change of colour; 4. That it be weighed while still warm, and immediately on being turned out of the vessel. This last precaution is as indispensable as the preceding ones; these organic matters having, in fact, such an affinity for water, that in the space of a few minutes, and while cooling, they absorb an appreciable quantity, which continues to increase, and at length becomes very considerable, if the process be carried out in a damp locality.

The absorption of water takes place with equal facility when the inorganic mass is left in a cold capsule, as when freely exposed to the air. The intervention of this water might, if not taken into account during the process of weighing, seriously modify the results; we may state, moreover, that it is quite as difficult to drive off the absorbed fluid, as the last drops of water which remained previous to complete desiccation.

The results appended below, were deduced from experiments made upon 100 grammes (3 oz., 1 dr.) of serum, taken from different specimens of blood; one portion of this serum, having been carefully dried, was allowed to remain for twenty-four, and another portion for forty-eight hours, in a warm, dry apartment, without any draught of air, and at a temperature varying from + 8 to + 10 degrees, centigrade measure.

Dried residue of 100 grammes of serum weighed while still warm.	The same weighed after twenty-four hours.	Mean difference, indicating the amount of water absorbed.
9.000	9.638	0.638
8.478	8.860	0.382
9.264	9.545	0.381
8.714	9.261	0.456
	The same weighed after forty-eight hours.	
9.384	11.144	1.760
9.017	10.755	1.738
8.526	10.150	1.624
7.970	10.010	2.040
9.350	11.205	1.855

Should we now wish to refer the above results to the standard of 1000, as is usually the case when analyzing the serum (and this may easily be done by placing the comma after the second instead of the first figure), it will soon be perceived that the results thus obtained are most inaccurate, and that the entire analysis rests upon a false basis.

The same deductions are alike applicable to the following results, as we shall briefly point out. They are intended to show, that the affinity of the blood for water is equally marked when dried *en masse.*

35.567 of solid matters of the blood, carefully dried *in vacuo*, absorbed, in twenty-four hours, 1.422 of water, which, if referred to 1000 grammes of fluid blood, would have led to an erroneous calculation.

The absorption of water takes place with considerable rapidity. The following is the result of two experiments, made with the view of ascertaining the amount of absorption of this fluid by the albuminous matter of the blood, during the first ten minutes after its exit from the apparatus.

1. 100 grammes of dried blood gave 19.901 of solid matter, weighed while still warm; ten minutes afterwards, the same mass weighed 20.067.

2. 100 grammes of dried blood weighed, when warm, 19·814; and ten minutes afterwards, 19.864.

The following experiments shew the results obtained from the same blood, at different intervals. They refer to defibrinized blood alone.

Solid product weighed while warm.	Ditto after 5 minutes.	Ditto after 20 minutes.	Ditto after 30 minutes.	Ditto after 1 hour.
36.63	36.67	36.72	36.78	36.90

We have expressly made use of the somewhat vague expression, *albuminous matters*, as it is somewhat difficult to decide positively, whether it be the albumen or the other materials of the blood, that possess such an affinity for water. Certain experiments, however, authorize us to suppose that this property belongs especially to the alkaline salts, the free soda, and the soluble extractive matters.

ARTICLE II.

OF THE EVAPORATION OF THE WATER OF THE BLOOD, WHEN EXPOSED TO THE AIR FOR THE PURPOSE OF SPONTANEOUS COAGULATION.

When the blood, at its exit from a vein, is not removed from atmospheric contact, a certain quantity of the water which it contains evaporates, and the relation between the solid and fluid portions, is altered; the former becomes concentrated; and were blood thus modified to form the basis of our analyses, serious errors might ensue.

The evaporation of the watery portion of the blood depends upon the three following conditions:

1. The extent of surface afforded by the vessel containing it.

2. The temperature of the surrounding atmosphere. During the summer heats, for instance, it is not an uncommon thing, in the hospital wards, to find blood that has been drawn and received into large vessels, reduced by spontaneous concentration to one-third of its original volume.

3. The amount of moisture existing in the atmosphere. Thus, three experiments were made in our laboratory, at a temperature of from 16 to 17 degrees centigrade (62° Fahr.),

in porcelain vases about 6 centimetres in diameter, and presenting, consequently, an evaporating surface of about 27 centimetres square (10 inches); the blood was received into vessels, immediately on being drawn, and then weighed; this was repeated, after the lapse of two hours; and again, after twenty-four hours.

The following were the results afforded:

	Weight of the blood at its exit from the vein.	Ditto, ditto, 2 hours after.	Ditto, ditto, 24 hours after.	Product of desiccation.
1.	13.242	13.070	11.510	2.45
	(185.01)	(187.4)	(212.9)	
2.	14.905	14.727	12.977	2.98
	(199.9)	(202.3)	(229.6)	
3.	22.453	22.308	20.337	4.21
	(187.5)	(188.7)	(202.4)	

This table may serve to give an idea of the evaporation which takes place in a moderately damp, warm locality. The figures included within brackets are intended to show the results that would have been attained by referring the calculation to 1000. Thus, the solid portions of the blood, which, when first drawn, would have been represented by the figures 185·01, 199·9, 187·5, would, after the lapse of twenty-four hours, have been represented by 211·9, 229·6, and 202·4.

At a lower temperature, the evaporation is of course less. The two following experiments were made upon serum, after free exposure to the atmosphere, at a temperature of + 10 degrees centigrade (50° Fahr.), in a vessel presenting about 60 centimetres (25 inches) evaporating surface, and of moderate depth.

	Weight when drawn.	Ditto 24 hours after.	Weight of dried product.
1.	38.0	35.5	3.10
	(81.6)	(87.3)	
2.	57.75	52.	4.20
	(76.8)	(80.8)	

We shall conclude this subject, by giving the results of two experiments made upon blood received into a vessel, having an evaporating surface of 75 centimetres square*, but at the same time very deep; and hence, as might be supposed, a less probability of error in estimating the proportion of solid matters in 1000 grammes.

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* About 30 square inches.

	Weight when first drawn.	Ditto after 24 hours.	Weight of dried product.
1.	209.3	204.9	40.0
	(191.1)	(193)	
2.	198.3	193.1	35.5
	(179.0)	(183.1)	

It were needless to adduce further proofs; and we are now in a position to draw some important conclusions from the above experiments.

The blood, at its exit from a vein, if received in an open vessel, and freely exposed to the air, loses by evaporation a portion of its water; and hence such a concentration of its solid ingredients, as would render the results of an analysis utterly erroneous.

As this evaporation is both continuous and considerable, it must be avoided by receiving the blood into a deep, narrow vessel, which is to be hermetically sealed, until the fluid be required for experiment.

It may not be amiss here, to mention another reason for basing our calculations upon relative rather than upon absolute quantities, both of which must be referred to the number 1000. It is as follows.

When the blood which is to be analyzed, with a view of ascertaining the weight of the globules and of the solid ingredients of the serum, is received into a vessel, for the purpose of spontaneous coagulation (we presuppose the causes of error mentioned above to have been avoided), the next step consists in drying separately the serum and clot, and then mixing the dried products, in order to deduce the sum total of the solid matters of the blood, and the weight of the water.

Now, to accomplish this twofold desiccation, it becomes necessary to pour off into separate vessels, both the serum and the clot; and this operation may even require to be repeated a third time, before placing them in the drying apparatus. In thus changing the vessels, there invariably remains a small amount of serum, which, adhering to the side of the vase, is either overlooked or lost, and hence a marked error in the analytical results. This may readily be conceived, inasmuch as it is necessary to add, on the one hand, the sum total of the serum, first when liquid, and subsequently when dried, to the sum total of the product afforded by the clot under analogous conditions,—viz., first liquid, and then dried,—in order to deduce from such addition (nought of which can be subtracted without affecting the ultimate results) the bases of the analysis of the blood, to be afterwards referred to the numerical standard previously adopted, viz., 1000.

Numerous experiments, upon which it is needless here to dwell, have clearly demonstrated the reality of the above soucre of error, and its influence upon the results of analysis; for this reason it is, that we never operate upon any but relative quantities, inasmuch as whatever quantity be employed, the proportion between the water and the solid matters remains the same.

ARTICLE III.

OF THE DENSITY OF THE BLOOD AND SERUM, AS COMPARED WITH THEIR CHEMICAL COMPOSITION.

The density of the blood, as it exists within the vessels, cannot be determined with accuracy; for no sooner does it escape from the vein, than coagulation commences, and there occur such changes in its volume as preclude all attempt to ascertain its real density. If this be the case when vessels of a given density are employed (as we have often found), *à fortiori* do we maintain the same conclusion, respecting the results afforded by an aerometer immersed in the blood, at the moment of its exit from the vein, whatever precautions be taken during the operation to maintain its original temperature. All calculations based on such data can only lead to erroneous conclusions.

It is more easy, however, to determine the density of defibrinized blood; and if a comparison be drawn between it and distilled water, at the same temperature, and in equal volume, we obtain precise and comparable results, provided always that the specific gravity be accurately ascertained, by careful measurement in a specific-gravity bottle. The aerometer would here lead to no definite result; it is intended merely to point out the density of liquids holding matters in solution, and not suspended corpuscles (globules).

At an early period of our investigations, we had repudiated the employment of the aerometer, the density of the different specimens of defibrinized blood having been ascertained by means of a specific-gravity bottle, avoiding, at the same time, the above-mentioned causes of error.

The results, however, thus obtained, did not appear to be conclusive; for no direct and accurate relationship was found to exist between the weight of the water and solid matters, and their corresponding densities: a tolerable approximation was all that could be obtained, even when using somewhat large vessels, and weighing their contents with the utmost exactness.

Basing, then, our proceedings upon these approximative results, we endeavoured to frame a corresponding table of densities, allotting to each the figures which represented the amount of solid matters held in solution or suspension in the water. This plan, however, was soon rejected, on finding that, while such a table might afford a very considerable approximation, it was not only impossible to ascertain the specific gravity by means of an aerometer, but that it was always necessary to have recourse to the specific-gravity bottle, double weighings, and lastly, to a correction for the difference of temperature. The table, therefore, which we had drawn up was laid aside, and we should not have alluded to it here, had not the work of an Italian physician, M. Poli, appeared to us capable of leading others into error, by the apparent simplicity of the means which he proposes for ascertaining, with an aerometer, and in a very short time, the chemical composition (approximative, it is true) of the blood. M. Poli conceives it possible to obtain this result by employing an aerometer, which shall give in succession, by its immersion, and the figure at which it stops, the composition, as regards water and solid materials,—first, of the blood itself, and, secondly, of the serum; each being exposed to a temperature of from 35 to 40 degrees (95° to 104° Fahr.), in a sand bath. The calculation necessary to obtain such a result being, according to M. Poli, exceedingly simple.

We consider it, however, totally impossible for this process to afford even a chance of accuracy; and any table constructed upon such a base cannot but be erroneous.

If, however, the density of the serum of the blood be ascertained, the results will prove far more accurate and decisive, although, still often, but approximative.

By reason of the soluble condition of the different constituents of the serum, we at one time thought of employing a delicate and well constructed aerometer, in order to determine its density. Experience, however, soon caused its rejection; and for the following reason: the albumen, which constitutes the largest portion of the solid matter of the serum, has a very low specific gravity—little, indeed, above that of water; and hence, in using a delicate aerometer, with a long stalk, and the intervals between each degree divided into tenths, it was found that the instrument often marked the same degree, or fraction of a degree, in specimens of serum which contained, for every 1000th part, very different proportions of solid matters. It was necessary, therefore, as with the defibrinized blood, to employ the specific-gravity bottle, and to have recourse, moreover, to repeated and careful weighing, at the same temperature. By this means, we have been enabled to obtain the density of the serum in about three hundred cases. These data permit of our establishing certain generalities, deduced from the results of the above experiments.

1. In many cases, the specific gravity shews the direct relationship existing between the water and the solid matters of the serum; hence it follows that, whether in the same or in different diseases, a similar proportion of the solid matters held in solution in 1000 grammes corresponds to a like specific gravity.

2. This, however, is not invariably the case; and we sometimes find the same numerical density corresponding to different proportions of solid matters in solution, and *vice versâ.*

In such a case, we have observed, that when the solid portion of the serum is so constituted as that the sum total of the extractive matters, fatty matters, and free salts, forms a ninth part, and the albumen eight-ninths, the relationship indicated by the specific gravity is tolerably constant and accurate.

2. When pure albumen preponderates, this relationship changes, and the numbers which denote the weight of the solid matters correspond to lower specific gravities.

3. When, on the contrary, the extractive matters and free salts are in relative excess, constituting, in fact, one-eighth or one-seventh of the solid matters, the relationship is reversed, and a higher specific gravity corresponds to the figures which indicate the aggregate weight of the solid portions of the serum.

4. In some still rarer cases, the fatty matters being in excess, this latter result does not take place, and the specific gravity may even decrease.

ARTICLE IV.

THE VARIATIONS IN COMPOSITION TO WHICH THE SERUM OF THE BLOOD IS LIABLE, WHETHER IN HEALTH OR DISEASE, CAN ONLY BE DETERMINED BY COMPARING SPECIMENS OF SERUM ONE WITH ANOTHER, AVOIDING ALL INTERMIXTURE WITH THE OTHER PRINCIPLES OF THE BLOOD.

On looking over certain tables relative to the alterations of the blood, which have been drawn up during the last few years, by those who make its analysis a special subject of investigation, we cannot but notice the following singular result.

In these tables (and we ourselves confess to having acted thus in our earlier analyses) are found classed under one head, and in order to make up the sum total of 1000: 1. The water; 2. The fibrin; 3. The globules; 4. The solid matters of the serum. While, therefore, in such an analysis, the figures which represent the weight of the globules and that of the fibrin may lead to certain general results in connexion with disease, nothing of the kind takes place with regard to the solid matters of the serum. In fact, if we except perhaps Bright's disease, an inspection of the numbers, which in these tables indicate the weight of the solid matters, affords no comparable result. For in the same diseases, and in individuals whose general conditions are identical, the figures are found to be most dissimilar, varying sometimes in one direction, sometimes in another; and even in the same person, after two separate bleedings.

This apparent diversity of composition is so evident, that the majority of experimentalists have ceased to draw the slightest conclusion from the results of analyses as applied to the solid matters of the serum.

One other observation will render the above result still more readily conceivable, and permit, in some sort, of its explanation.

We have noticed that in the analyses of different specimens of serum, affording, as not unfrequently happens, by the process of desiccation, the same numerical amount of solid matters, we no longer obtained the same agreement on referring the entire results of a complete analysis of the blood to 1000 grammes. These identical specimens of serum, taken from blood containing different proportions of globules, were represented by numbers, indicating a certain amount of solid matters, varying according to the excess or deficiency of the globules, and consequently in an inverse ratio to these last, and yet the proportion between the water and the solid matters was not found to have varied. No change had taken place, save in the serum, the excess or deficiency of which required to be added to the globules, in order to obtain the sum total of 1000 grammes.

To understand the above result, which is of great importance, constituting as it does our starting point in the new track which we have since trodden, an example is necessary.

Two individuals are bled; the composition of the blood drawn is such, that the results, when referred to 1000, are as follows:

For the first . .	850 of water, and 150 of solid matters.
For the second .	750 of water, and 250 of solid matters.

These two specimens being set aside, and the separation between the clot and serum having taken place, each is to be dried separately, and the result will be, that, in spite of the difference of the aggregate weights, the composition of the serum remains the same. Thus, in the first case, 100 parts of dried serum contain 10 of solid matter; while the same proportion obtains in the second case, viz., 10 per cent.

If, then, we introduce into our calculations respecting the composition of the blood these identical specimens of serum, we have the following:

In the first case: 850 of water : x :: 90 : 10, or $x = 94.4$, which, subtracted from 150, in order to obtain the weight of the globules, gives 55.6.

In the second: 750 of water : x :: 90 : 10, or $x = 83.3$, which, subtracted from 250, to ascertain the weight of the solid matters, gives 166.7.

On combining the above calculations, we find:

	In the first case.	In the second case.
Water	850	750
Globules	55.6	166.7
Solid matters of the serum .	94.4	83.3
	1000.0	1000.0

Here, then, we have two specimens of blood, the serum of both of which is identical in composition, while the solid matters are represented by essentially different numbers, for the sole reason that they are intermixed with a different proportion of globules. There is, however, no real change in all this, for the ratio of the water to the serum remains always the same in either case, and thus the proportion 850 : 94.4 :: 750 : 83.3 is perfectly accurate.*

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* We have here chosen figures which, while arbitrary, are sufficiently

What, then, are we to conclude from the above results? Clearly this: that to arrive at a knowledge of the influential agencies presiding, as it were, over the composition of the serum and the variations of its solid matters, we must compare this fluid with itself, and invariably refer the calculation to 1000, in order to obtain an accurate numerical standard of comparison.

This is precisely the course we have adopted.

We may state, moreover, that after every analysis of the blood, the acquired results ought to be regarded in a two-fold point of view, and placed, as below, under two distinct separate headings.

In the first, for example, as follows:	*In the second:*
Composition of 1000 parts of serum.	Ditto of 1000 parts of blood.
Water	Water . . . . .
Solid matters of the serum	Fibrin . . . . .
	Globules . . . .
	Solid matters of the serum

In the second table, the solid matters of the serum are not represented by a number susceptible of comparison with their corresponding figures.

The only composition of the serum admitting of comparison is that found under the first heading.

We lay, however, no claim to priority in pointing out this difference in the results, or in having shewn the necessity of adopting the method just described, in the analysis of the blood: it had been already recommended, and even executed, by MM. Prevost and Dumas, in their first remarkable memoir on the analysis and composition of the blood, published upwards of twenty years ago.

We have, however, thought it expedient to dwell somewhat minutely on these details, inasmuch as they seem to have been completely overlooked: for since the memoir of the above

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simple to allow the calculation to be followed out. Experiments, however, tending in the same direction, have been made by us repeatedly: they are described in certain tables laid before the Academy of Sciences, but we purposely omit them here as being of no service to the reader.

illustrious chemists, no mention whatsoever has been made of them. Hence, doubtless, the reason why it has been hitherto impossible to ascertain the general principles which regulate the modifications of the solid matters of the serum; it would, however, be comparatively easy to reconstruct the composition of the serum, such as we have shewn it to be, by means of a simple sum in proportion, the sole data requisite being the representative numbers of the water and of the solid matters.

Before stating the conclusions to which we have been led by an analysis of the serum of the blood, whether in health or disease, we shall briefly point out certain general facts deducible from an examination of the serum, and even of the blood itself, irrespective of the physiological or pathological condition of the individual from whom it has been withdrawn. These facts may be arranged in two groups, which we shall proceed to examine in succession.

FIRST GROUP. *The blood which escapes when a vein is first opened, is not precisely identical in composition with that which flows after the lapse of several minutes; the latter contains less solid matter, and consequently more water, than the former.*

This fact has been already noticed by MM. Dumas and Prevost in the memoir previously quoted: following in their track, we have endeavoured—1. To establish its occurrence in the case of human blood; 2. To ascertain whether it can happen within the restricted limits of a single bleeding; and, lastly, if not to measure the degree of alteration with exactness, at least to do so approximatively.

Considered in an absolute point of view, it is probable that this deterioration in the quality and richness of the blood takes place by continuous progression, beginning, in fact, with the first drop which escapes, and ceasing only with the last; it is easy, therefore, to conceive the difficulty of ascertaining the degree of impoverishment with even moderate accuracy.

If, however, it be difficult to determine the solution of this problem with mathematical precision, we may at least obtain an approximative valuation, by carefully collecting every 100 grammes of blood as it escapes from the vein, and drying it immediately with all the requisite precautions.

From among the oft-repeated experiments which we have made, with a view to ascertain, as accurately as possible, the degree of impoverishment of the blood, and by adopting the method recommended in the preceding paragraph, we shall select six examples, for the purpose of shewing the modifications to which the three principal elements of the blood are liable.

TABLE.

Experiment 1.* Blood dried (en masse).			*Experiment* 3. Serum.		*Experiment* 5. Fibrin.†
	Water.	Solid matters.	Water.	Solid matters.	Amount of Fibrin.
1. Q. 100 grs.	83.29	16.71	90.58	9.42	0.867
2. Q. 100 „	83.39	16.61	90.59	9.41	0.872
3. Q. 100 „	83.50	16.50	90.62	9.38	0.881
4. Q. 100 „	83.68	16.32	90.63	9.37	0.859
Experiment 2.			*Experiment* 4.		*Experiment* 6.
1. Q. 100 grs.	81.01	18.99	91.10	8.90	0.242
2. Q. 100 „	81.37	18.63	91.10	8.90	0.214
3. Q. 100 „	81.54	18.46	91.11	8.89	0.208
4. Q. 100 „	81.80	18.20	91.14	8.86	0.217

A glance at the above table leads to certain conclusions of considerable importance. If we divide a portion of blood weighing 400 grammes (12½ oz.) into four equal parts, and dry it with the utmost care, each part will be found to contain a smaller proportion of solid matter than that which preceded it, in the order of exit from the vein. The degree of impoverishment is not, however, the same at every period of the flow; we repeat, it is progressive; and moreover, the fractional divisions employed in the preceding table are rather intended to give a general idea, than an exact measure of the change which takes place.

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* The six experiments of which this table constitutes a resumé, were made upon six different specimens of blood, *i.e.* drawn from different individuals.

† The fibrin was collected in the following manner : 100 grammes of blood having been received in a vessel (this vessel being weighed both before and after), the blood was deprived of its fibrin in the usual manner, dried, weighed, and the result referred to the numerical standard of 100, in order to avoid fractions. We have adopted this method of procedure for some time past, preferring, in our earlier researches, to extract the fibrin from a given weight of blood, rather than employ comparative volumes.

The decrease in the solid matters takes place chiefly at the expense of the globules, as well as of the solid matters of the serum; but this last to a small extent only, as shown by referring to the third and fourth experiments in the preceding table.

As regards the fibrin, its relative proportions seem to vary but little during each quarter of the experiments here quoted. The difference noticed in the decimals can only be attributed to slight errors, inseparable from such proceedings.

Whence arises this impoverishment of the blood? and how does it take place? The explanation is difficult; and in the present state of science, we must admit that given by MM. Dumas and Prévost, which we shall reproduce in the words of the authors themselves, applying them, however, to man instead of to animals, as they have done.

"When a large quantity of blood is withdrawn from a small "animal, the veins rapidly absorb, at the expense of the re-"mainder of the system, an amount of liquid proportionate, "and perhaps equivalent, to that which the circulating mass "has lost; whence it follows, that in a given quantity of blood "the particles appear to diminish."*

The results at which we have arrived, together with our explanation of the same, possess a certain degree of importance. The impoverishment of the blood being merely apparent, and arising, in all probability, from the absorption, by the veins, of a volume of water, destined to replace that of the blood which has been abstracted, it of necessity follows, that we cannot indifferently select the different portions of a somewhat large bleeding, for the purpose of analysis, or with a view of ascertaining the exact composition of this liquid, as it exists in the organism at the moment when the vein is opened.

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* Annales de Physiologie et de Chimie, t. xxiii, p. 67.

To determine, then, the composition of the blood, we must operate upon the first 100 grammes (3⅓ oz.) that are drawn; the impoverishment which takes place during its flow being so trifling, as to admit of our passing it over without inconvenience. The analysis, therefore, of this portion will serve as a starting point or standard of comparison, in every case, and may be considered as representing the exact composition of the blood at the moment the operation is performed.

SECOND GROUP.—*On the influence of previous bloodlettings on the composition of the serum of the blood.*

Repeated bloodlettings exercise a marked influence upon the composition of the serum. If an individual be repeatedly bled, his blood becomes impoverished; the solid matters—and especially the globules—decrease with a rapidity proportionate to the abundance and frequency of the venesection.

Does the same thing occur in regard to the serum, considered without reference to the weight of the fibrin and globules? Frequently repeated experiments permit of our affirming that it does so, and that, in proportion to the frequency and copiousness of the bleedings, there occurs a diminution of the solid matters, varying exceedingly in degree at different times, and usually under the influence of certain conditions which admit of being appreciated.

The first is, to experiment only upon the serum of different specimens of blood, drawn at comparatively *short* intervals of time, such as twenty-four and forty-eight hours, and for the *same* disease. If a longer period be allowed to elapse, and that the bleeding be repeated on account of some complication, comparison is no longer possible, since, during the interval between the two operations, the serum may have either completely recovered its loss, or have undergone some new modification.

Bearing these circumstances, then, in view, we have endeavoured to determine what might be the average degree of impoverishment of which the serum is susceptible, under the influence of repeated venesection, performed at *short* intervals, for the *same* morbid condition.

The mean here, as in all other modifications to which the blood is liable, cannot possess any absolute value, being intended merely to impress on the memory the approximative degree of this impoverishment in twenty-seven individuals, labouring under certain diseases, and in each of whom two venesections, at least, were practised. The mean density of the serum, as contrasted with that of an equal volume of water (1000), was represented by 1026.9. The mean density of the serum afforded by the twenty-seven second bleedings, repeated after a short interval of time, was represented by 1025.4. Between the two operations, therefore, we notice a marked decrease in the density to have taken place.

Of these twenty-seven individuals, seven were bled thrice. The mean density of the serum of the seven cases in which the bleeding had been repeated, was 1027. The mean of these same cases, after it had been performed three times, was 1025.7; shewing a progressive decrease in the density of the serum.

If now we refer the composition of the serum to the standard of 1000, we obtain the following mean results:

	Solid matters of the serum.	Water.
1. Venesection in 27 individuals, mean weight .	86.5	913.5
2. Venesection in 27 individuals, mean weight .	81.4	918.6

Of these twenty-seven individuals, seven, as we have said before, were bled three times.

The mean of the seven second bleedings gave .	84.2	915.8
The mean of the seven third bleedings gave .	82.1	917.9

SECTION IV.

GENERAL RESULTS OF THE ANALYSIS OF THE BLOOD.

OF THE MODIFICATIONS TO WHICH EACH CONSTITUENT PRINCIPLE OF THE BLOOD IS LIABLE.

ARTICLE I.

OF THE WATER.

The average amount of water contained in the blood, may be reckoned at from 780 to 800 in 1000 grammes (31¼ oz.) of blood, or from 880 to 900 in 1000 grammes of serum.

The specific gravity of the blood is in direct relation to the proportion of solid matters which it holds in solution or suspension. One fact, however, here deserves notice, viz., that on account of the discrepancy occasionally observed in the relative proportion of the extractive and fatty matters, as well as of the free salts and albumen, all of which are held in solution by the serum, this relationship does not always exist. Thus, in two specimens of serum of like density, desiccation may give a different weight of solid matter; just as two specimens of different density may, when dried, afford each a solid residuum of equal weight.

The numerical density may, nevertheless, be generally regarded as being in direct ratio to the quantity of water existing in the blood.

The proportions of water alluded to above, are susceptible of considerable variation; and they have sometimes been observed to oscillate between 880 and 740, *i.e.*, in the proportion of 140 grammes (4⅝ oz.) of water for 1000 grammes (31¼ oz.) of blood. It may be laid down, then, as a general rule, that the quantity of water contained in the blood is in inverse ratio to that of the solid matters entering into the composition of this fluid. The greater the proportion of these last, the more does the water diminish, and *vice versâ*. This conclusion is, however, somewhat too general; and in order thoroughly to appreciate the changes which the water may undergo, we must examine the variations of this liquid, in relation—first, to the globules, and then to the albumen.

With regard to the globules, we may state, that the more numerous they are, the smaller is the quantity of water, and *vice versâ.* As for the albumen, its variations are analogous; but they must be studied in the serum only, and after being separated from the blood. When the globules and the albumen of the blood are simultaneously diminished, the water undergoes the greatest increase; when the globules alone are diminished, the increase in the quantity of water is less; when the albumen alone is diminished, the quantity of water increases in a still smaller proportion.

We shall now examine the variations which the water may undergo in different pathological conditions.

And first, it may be stated, that in various morbid conditions of a subacute rather than of an acute character, in certain phlegmasiæ, and in some well marked chronic diseases, the proportion of water in the blood remains within physiological limits, and undergoes but slight variation. The same takes place in slight indispositions, uncomplicated nervous affections, etc.

The proportion of water may diminish. The fact of such diminution must always be admitted, when the water does not amount to 720 parts in 1000. This, however, is very rare; much more so, in fact, than its increase. We have found it to occur in certain cases of plethora, of simple jaundice, and especially in epidemic cholera. With these exceptions, a diminution of the watery element of the blood is altogether fortuitous, nor can aught that is positive be said of it.

If, however, the diminution of the water be thus rare, nothing is, on the other hand, more common than to find it increased, even to a considerable degree, in a variety of morbid conditions*. This increase may vary from 20 up to 80 grammes.

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* Such is the influence of sex, that the water is invariably found in

When the increase is but trifling, it usually results from one or other of the following causes: insufficient alimentation; low diet, when prescribed for a patient not suffering from a febrile affection; acute diseases, especially at their outset; nervous affections, of moderate severity; and certain trifling chronic diseases.

A great increase of the water takes place after prolonged fasting, absolute starvation, loss of blood, profuse discharges and suppurations, dropsies, chronic diarrhœas, and salivation; also, in certain cachexiæ, such as the saturnine and marsh cachexiæ, and in the tubercular and cancerous diatheses. These examples will suffice, as being those in which the increase of the water of the blood is most commonly noticed.

ARTICLE II.

OF THE GLOBULES.

The blood globules are of two kinds: the first are extremely numerous, of regular and unvarying dimensions,—these are the red globules; the second are few in number, of somewhat irregular form, and of variable dimensions,—these, which are the white globules, are in all probability nothing more than a number of chyle globules. We shall here treat of the red globules alone.

The blood globules, examined under the microscope, present the appearance of small discs, of a pale rose colour, having a diameter of $.0,006_{m}$;[*] their edges are somewhat elevated and their centres depressed. We remark, moreover, that their borders are opaque; while towards the centre they are partially transparent.

The blood globules are not simple fibro-albuminous bodies; they are composed of a vesicular envelope, the contents of

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larger proportion in the blood of the female than in that of the male. The same may be said with regard to the influence of age, the preponderance of the watery element being greatest in childhood.

[*] About $\frac{1}{3500}$ of an inch.

which are intimately connected with the colouring matter of the globule.

It is difficult, if not impossible, to ascertain directly the weight of the globules: as we have previously had occasion to state, their approximative weight can alone be determined; but as the same method of procedure is adopted in every analysis, it follows that, should there be an error, it will be repeated in every case in the same proportion, the general results remaining the same. We have, however, discussed this question at page 22, to which we refer the reader.

The mean amount of globules contained in 1000 parts of blood may be taken at 135 for the two sexes: for the male, 140; for the female, 125. The physiological limits may be fixed at from 125 to 145. If, in other words, they exceeded 145 parts or fell below 125 parts in 1000, such increase or decrease would merit special notice.

The globules remain within physiological limits in a great variety of circumstances. As, for example, in the majority of slight acute diseases, in nervous affections, and in chronic diseases, either of moderate severity or which have not invaded organs essential to life. The same may be said of many cerebral affections.

Sect. I.—Increase of the Globules.

An increase in the proportion of the globules is a fact as well established, although far more uncommon, than their decrease. We have only observed this increase in the following cases: 1. In some plethoric individuals, but not in all; 2. In some cases of uncomplicated jaundice; 3. In a certain number of cases of epidemic cholera. With these exceptions, we regard the increase of the globules as an exceptional fact, which admits of no general application.

Sect. II.—Decrease of the Globules.

A decrease in the proportion of the globules is an exceedingly common pathological occurrence. It may vary greatly in degree, the reduction extending sometimes to 40 parts in 1000;

and it is this which constitutes the anatomical characteristic of that morbid condition known by the name of anæmia, and more particularly symptomatic anæmia. To study this decrease in the globules, we must take into consideration the extent to which it occurs. We therefore admit a *trifling diminution*, when the globules are represented by figures ranging between 100 and 120; a *medium decrease*, when the figures range between 80 and 100; and lastly, a *considerable decrease*, when they range from 80 to 40.

Premising this, let us now examine in succession these three different degrees of diminution on the part of the globules.

A. *Slight diminution* (globules ranging between 100 and 120).—This diminution is evinced by the occurrence of the following symptomatic phenomena: the individual feels somewhat debilitated; his face is pale, and he probably presents a basic systolic murmur, and an intermittent souffle in the carotids. These modifications of the natural sounds may, however, be wanting, and they are so more frequently, when the figures representing the globules range between 110 and 120, than when between 110 and 100. There is, however, no absolute certainty on this point.

This slight decrease of the globules is met with under the following circumstances, viz., in persons of feeble constitution, presenting the marks of what is commonly called the lymphatic temperament. It may likewise be caused by insufficient food, by residence in a damp and marshy locality, by the privation of solar light, and by certain morbid conditions: thus, for instance, it is not uncommon to find this condition of the blood after copious venesection, whether general or local; after the repeated employment of purgatives; during the transition from the acute to the chronic stage of Bright's disease; and after the first few days of an acute disease, whether it be a fever or a phlegmasia. It occurs also in the earlier stages of certain chronic diseases; at the commencement of a cachectic condition; in the various diatheses; in constitutional syphilis; and lastly, in chronic uterine catarrh.

It is utterly useless to administer the preparations of iron, with a view of combating the diminution of the globules in the above category of morbid conditions. It is sufficient to remove the exciting causes, whatever they may be, and to employ hygienic measures, together with due attention to regimen.

B. *Medium decrease* (the globules ranging between 80 and 100 per 1000).—This modification of the blood is characterized by more decided debility on the part of the affected individual. The surface is pale, and often presents a yellowish tinge; exertion is difficult and distressing; various nervous symptoms, depending on special idiosyncrasy, begin now to appear; there is slight palpitation and dyspnœa after walking, or any other kind of muscular exertion; lastly, we detect a basic systolic murmur, which is very marked (although intermittent) in the aorta and carotid arteries, but is rarely propagated to the more distant vessels.

The causes capable of producing this modification of the blood are numerous. Without recapitulating them, we may state, that those previously enumerated in connexion with a trifling decrease of the globules, suffice, when existing in a more marked degree, to produce that condition of which we now speak. It is proper, however, to enumerate among the more special causes—considerable loss of blood; prolonged diarrhœa; marsh cachexy; saturnine anæmia; organic diseases of the heart, at a certain stage; chronic Bright's disease; the last stage of chronic diseases in general; and lastly and especially, chlorosis.

When the globules range between 80 and 100, a special treatment is necessary, independent of the original disease. For although it is certain that no practical results can be obtained, as long as the disease which gives rise to this condition of the blood exists, yet, when removed, it may happen that a long period elapses before the globules regain their normal proportion. For this reason, a ferruginous treatment is indicated, and should always be recommended,—provided, indeed, that the original disease be not seated in the digestive organs.

C. *Maximum decrease of the globules* (from 80 to 40 per 1000).—This condition of the blood is far less frequent than

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the preceding. It is evinced by the following symptomatic phenomena: the skin is colourless, or of a greenish yellow tinge; the strength is diminished; the slightest exercise, and sometimes even the most trifling muscular effort, suffices to produce muscular pains, dyspnœa, and palpitation. Cephalalgia, vertigo, tinnitus aurium, and other nervous symptoms, are also present, but vary greatly in intensity. Syncope takes place with the utmost facility; the pulsations of the heart are more frequent than natural, and the pulse presents similar characters; a basic systolic murmur likewise exists. In the carotid arteries a very loud, intermittent, humming *bruit de souffle* is heard, and a continuous hum in the veins, of greater or less intensity: this last is rarely wanting.

It is more especially in cases of chlorosis, or where the nervous element preponderates, that the continuous murmur in the vessels of the neck is audible.

The maximum decrease of the globules occurs after repeated copious bleedings; after severe hæmorrhage; in acute chlorosis; in the anæmia resulting from marsh miasm; and in the advanced cancerous cachexy,—more especially when the disease is seated in the stomach.

If a moderate decrease in the relative proportion of the globules requires the administration of ferruginous preparations, the condition of which we are now treating does so in a far greater degree. It must, however, be borne in mind, that the disease which gives rise to this modification of the blood, demands our first consideration.

ARTICLE III.

OF THE ALBUMEN.

The albumen is held in solution by the serum of the blood; it is therefore fluid. Its reaction is alkaline, owing to its combination with a salt of soda as an albuminate of soda.

When treated at a temperature of about 75 or 76 degrees centigrade (184° Fahr.), albumen coagulates, and forms itself into a solid opaque whitish mass, which is no longer soluble; if it be dried only in the sun, or at a temperature of from 40 to 50 degrees (105° to 123° Fahr.), it assumes the transparency and consistence of gum, and may be redissolved in water. It coagulates on the application of sulphuric, nitric, hydrochloric, tannic and phosphoric acids, bichloride of mercury, alcohol, and creasote.

It possesses rotating properties; the ray of polarized light being deviated to the left by it. Its rotating power, in fifty specimens of serum, varied from 26 degrees 30 minutes to 28 degrees 30 minutes.

We have found, as the result of experiment, that each minute of deviation corresponds to a quantity equivalent to 18 decigrammes in 1000 cubic centimetres of water.* It follows, therefore, that the best method of ascertaining the amount of albumen, consists in examining the serum of the blood with the polarizing apparatus to which M. Becquerel has given the name of *albuminimeter*.†

Such was the actual condition of science till within a very short space of time, when an interesting memoir was published by M. Mialhé, in which he endeavoured to show that the albumen of the serum, like that of the white of egg, was not soluble, but that it existed in a state of suspension, in virtue of a special organization or true globular condition.

According to M. Mialhé, what has hitherto been regarded as soluble albumen, is in general but a modification of the albumen, viz., albuminose.

Without here discussing the question, we cannot yet give our assent to the above views, since, if the albumen were simply in a state of suspension, it would neither possess the deviating power previously mentioned, nor those other properties which it evinces in common with soluble bodies in general. The question is of but little importance, inasmuch as we have here but to deal with its proportion relative to the other ingredients of the blood. We shall, however, return to the subject when treating of Bright's disease.

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* About 27 grains in 400 cubic inches of water.

† Vide *Archives générales de Medecine* for 1850, vol. xxii, 4th series.

According to MM. Dumas and Cahours, the mean composition of the albumen in human blood may be thus represented numerically:

Carbon	53.32
Hydrogen	7.29
Nitrogen	15.70
Oxygen	23.69
	100.00

The proportion of albumen contained in the blood must not be referred to a given quantity of that liquid, 1000 grammes (31¼ oz.), for example; such an estimate would afford no positive result, and would be in inverse ratio to the weight of the globules. To ascertain the amount of albumen, it must be sought for in serum collected under similar circumstances, and then compared with other specimens of its kind. We shall now, therefore, proceed to investigate the amount of albumen contained in 1000 grammes (31¼ oz.) of blood, such quantity being estimated either by chemical or polarimetric analysis.

In the physiological state, 1000 grammes of serum contain 80 grammes (2½ oz.) of pure albumen. This number may oscillate between certain limits. We consider 75 to be the minimum, and 85 the maximum of such oscillation. It may, however, sometimes rise as high as 90, or fall as low as 70 per 1000.

A minimum proportion of the albumen, in the physiological condition, is more especially met with in persons of a pale complexion, in young subjects, and in those whose diet is not sufficiently nourishing. The maximum proportion occurs under directly opposite conditions.

Sect. I.—Increase of the Albumen.

(Proportion varying from 90 to 110 per 1000.)

An increase of the albumen is a rare and exceptional fact.

We know of no law upon which this condition of the blood can be said to depend; nor is it revealed by any special pathological phenomena. It is found under a variety of circumstances; and as yet we are ignorant of the causes by which it is produced. During our earlier researches, we frequently detected this condition of the blood in old persons suffering from paraplegia, the result of disease of the medulla spinalis, and who had remained bedridden for a great length of time. Since then, however, we have analysed the blood of several individuals placed in similar circumstances, but on none of these occasions has the serum afforded a larger proportion of albumen than usual.

SECT. II.—Decrease of the Albumen.

This decrease of the albumen is as frequent as its increase is rare. Admitting 70 to be the lowest limit of health, we sometimes find it descending as low as 40. In this scale we must, as in the case of the globules, admit three degrees.

A. *Slight decrease of the albumen* (ranging from 60 to 70 per 1000).—The consequences which result from this modification of the blood, vary in proportion to the rapidity with which it has taken place. When occurring suddenly, general anasarca ensues, as in the acute form of Bright's disease; it sometimes follows the sudden application of cold, as after scarlatina, while at other times no cause can be assigned for its appearance. As a general rule, this sudden diminution of the albumen takes place irrespective of the globules.

When of a chronic character, it is difficult to appreciate its effects upon the general organism, inasmuch as there occurs, almost invariably, a simultaneous decrease in the proportion of the globules. The debility and pallor of countenance may be equally well attributed to either of these morbid conditions of the circulating fluid.

This modification of the serum takes place, in a slight degree (from 65 to 70), during every acute febrile disease, more especially in the phlegmasiæ, and in typhoid fever.

It occurs in a somewhat greater degree, during the convalescence from acute diseases that have been protracted; after a long-continued system of low diet, bloodlettings, and profuse discharges; in chronic diseases that have already lasted a considerable time, and debilitated the system; in pulmonary consumption; and lastly, in anæmia, from whatever cause, provided only it be carried to a high degree.

In organic diseases of the heart, however, that have reached their second stage, a decrease of the albumen may occur, independently of the globules, and however large their proportion. In such a case, it is evident, that to the decrease of the albumen alone, must be attributed that debility of body, and yellowish pallor of countenance, which are characteristic of chronic heart disease.

B. *Medium decrease of the albumen* (ranging from 50 to 60 parts per 1000).—This condition of the blood is marked by pallid countenance, debility, and especially by anasarca. It may occur in either an acute or chronic form.

The acute form arises in certain cases of severe puerperal fever. The chronic form may be witnessed in some cases of pregnancy; in chronic Bright's disease; in the latter stages of chronic heart disease; and in acute marsh cachexia. In every case, such decrease is accompanied by dropsy.

C. *Maximum decrease of the albumen* (ranging from 40 to 50 parts per 1000).—This modification of the blood is exceedingly rare; constituting, indeed, an altogether exceptional fact. In an acute form, it may occur in some cases of puerperal fever, but it is not accompanied by anasarca. The chronic form may occasionally occur in severe cases of Bright's disease, that have lasted for some time; as well as in some diseases of the heart, of long duration and great severity.

This modification of the blood, when it assumes the chronic form, determines anasarca where it had not previously existed, and increases it when already present.

ARTICLE IV.

OF THE FIBRIN.

The fibrin of the blood, as usually obtained, is composed of greyish elastic filaments. After desiccation, it becomes yellowish, hard, brittle, and almost transparent. Immersion in water softens it and restores its natural properties.

It exists in the blood in a state of solution; and this condition is maintained in virtue of a peculiar vital phenomenon. When removed from the vessels, it coagulates spontaneously: it does so, likewise, after death.

The fibrin, after having once undergone coagulation, becomes insoluble both in water and alcohol; but it may be dissolved at a temperature of 200 degrees (centigrade measure), in a Papin's digester, or in an hermetically sealed tube.

After being treated with hydrochloric acid, a trifling degree of heat serves for its solution.

Water containing a thousandth part of hydrochloric acid causes the fibrin to swell, and transforms it into a transparent jelly, which may be dissolved by the addition of a few drops of rennet. Acetic acid has a similar effect.

Nitrate of potash and sulphate of soda, when mixed with blood, not merely prevent the fibrin from coagulating, but redissolve it after it has done so. According to MM. Dumas and Cahours, the mean composition of the fibrin in man may be thus represented:

Carbon	52.78
Hydrogen	6.96
Nitrogen	16.78
Oxygen	23.48
	100.00

Having already explained the means by which the fibrin is obtained, we need not here revert to the subject.

The mean amount of fibrin existing in healthy blood, may be estimated at 2.5. Its physiological limits may be placed at 2 and 3. Above and below these numbers, the proportion of fibrin must be regarded as indicative of some pathological condition. Circumstances connected with age, sex, constitution, habitation, diet, regimen, etc., probably exert some influence over the proportions intermediate between 2 and 3; but these influences are manifested by such trifling variations, that they have not hitherto been determined.

The fibrin may undergo increase or decrease, under the influence of a great variety of pathological causes. Let us, however, remark here, that while the increase of the albumen and globules is a rare occurrence, and their decrease a very common one; the contrary holds good with respect to the fibrin, for the elevation of its representative number is as frequent as that of the albumen and globules is the reverse.

SECT. I.—Increase of the Fibrin.

Between 3 and 10, the fibrin may present the various gradations of increase which such a scale affords; two broad divisions may, however, be established:

The first comprises those cases in which the number representing the fibrin varies from 3 to 5.

The second comprises those in which it varies from 5 to 10.

A. *Slight increase of the fibrin* (from 3 to 5).—This increase occurs under four essentially different circumstances, viz., 1. In chlorosis, properly so called: it constitutes, in fact, as we have elsewhere stated, one of the means by which to distinguish true chlorosis from anæmia; 2. During pregnancy, more especially towards its latter period; and it is not improbable that this increase of the fibrin may account, in a measure, for the facility with which the phlegmasiæ manifest themselves, during the puerperal period which follows the act of parturition; 3. In certain inflammations which, although slight, suffice nevertheless to produce febrile disturbance,—such as erysipelas of the face, angina, etc.; 4. In certain cases of scurvy, more especially when it assumes the acute form.

B. *A great increase of the fibrin* (from 5 to 10), is met with in the phlegmasiæ properly so called. The discovery of this important pathological law, to which there is perhaps no exception, is due to MM. Andral and Gavarret. This increase of the fibrin occurs in direct ratio to the intensity and extent of the inflammation. It is thus that in acute articular rheumatism, pneumonia, and pleurisy, the fibrin attains its maximum of elevation, sometimes rising as high as 10. Next in order come, peritonitis, bronchitis, erysipelas of the face, if severe, and the various other phlegmasiæ of different organs.

The question here suggests itself, whence this increase in the proportion of the fibrin? Is it the result of the transformation of a certain amount of albumen into fibrin? This is not improbable, and the decrease of the former, which we have previously stated to be a constant occurrence, appears to corroborate this hypothesis. Be this theory true or not, we may still ask what can be the cause, capable of either transforming a certain quantity of albumen into fibrin, or of creating this latter element *de novo*.

The elevation of temperature which characterizes the phlegmasiæ, has been appealed to; but can we legitimately adopt such an opinion, when we observe that in typhoid fever, eruptive fevers, etc., an equal elevation of temperature produces, or at least is accompanied by a diametrically opposite result, *i. e.*, a decrease of the fibrin. It is therefore to the essential element of the disease itself, the inflammatory condition, that we must attribute this modification of the blood, without going further to seek for an explanation, which in all probability would not be discovered.

An increase of the fibrin is characterized by a remarkable phenomenon; namely, a tendency to secondary inflammations. The diffuse nature of the joint affection in acute articular rheumatism, the occurrence of endocarditis in the course of this disease, as well as of pneumonia, pleurisy, etc., is, in all probability, a consequence of this increase on the part of the fibrin. As for the febrile condition, and the elevation of temperature of the cutaneous surface, they cannot be attributed to this condition of the blood, inasmuch as they frequently arise when it is absent.

SECT. II.—Decrease of the Fibrin.

When this occurs, the number representing the fibrin oscillates, for the most part, between 1 and 2. Rarely does it fall below 1; on one occasion, however, we found it as low as 0.8, towards the close of a very severe case of typhoid fever which terminated fatally.

The causes which give rise to this decrease of the fibrin are tolerably numerous; they may be divided into acute and chronic.

Among the former may be enumerated, severe typhoid fevers, especially of an *adynamic* type, small pox, scarlet fever, measles, etc.

It is probable that in the plague and in yellow fever, the decrease of the fibrin is considerable; but we possess no chemical analysis capable of substantiating this assertion. It is equally probable that the same modification of the blood occurs in the majority of severe intermittent fevers.

The chronic causes giving rise to a decrease of the fibrin are the following: organic diseases of the heart in their latter stages, certain marsh cachexiæ, chronic scurvy, and well-marked mercurial cachexia.

A decrease of the fibrin, whether of the acute or chronic form, is shown by the occurrence of a pathological phenomenon peculiar to it, and which may serve in some measure to detect its existence. This consists in a tendency to different forms of hæmorrhage, the seat of which varies with the nature of the organic lesions of the disease, during the course of which the decrease of the fibrin has taken place.

ARTICLE V.

OF THE FATTY MATTERS.

The blood contains several species of fatty matter, which are as follows:

Seroline;

Cholesterine;

Margaric, stearic and oleic acids, in the form of margarate, stearate, or oleate of soda or soap;

A phosphuretted fatty substance, the existence of which may be contested, and upon which we shall dwell more fully hereafter.

SECT. I.—Of the Seroline.

Seroline, discovered by M. F. Boudet, is a specific fatty matter, the existence of which cannot be doubted. We conceive ourselves to have been the first, and perhaps the only experimentalists, that have sought to determine its proportions.

We find then, as the result of analysis, that the amount of seroline existing in healthy blood may be estimated at from 0.020 to 0.025 in every thousand parts of that fluid. We have seen it rise as high as 0.060, and fall to an almost inappreciable quantity. With regard to the variations of which it may be susceptible through the instrumentality of disease, we as yet know nothing.

SECT. II.—Of the Cholesterine.

The cholesterine exists in the blood in much larger quantity than the selorine. Thus, for instance, we find as the result of numerous analyses, that the mean quantity of this principle in healthy blood varies from 0.090 to 0.100; we have seen it, moreover, rise as high as 0.175 and fall to 0.075. As the cholesterine may be obtained pure and isolated, the accuracy of these results cannot be doubted.

The increase of the cholesterine in disease, may be referred to the following circumstances.

1. In every acute febrile affection the cholesterine increases, on an average, about one-third; the causes of this we shall endeavour to explain hereafter.

2. In all acute inflammations the augmentation is still greater, and the amount of cholesterine may be estimated at nearly double its healthy standard.

3. In cases of jaundice, accompanied with retention of bile and paleness of the fæces, the cholesterine increases to a great degree, and its weight is sometimes found to be five or six times greater than in health.

As for the causes which may give rise to a decrease of the cholesterine, we know but little of them, nor have our analyses led to any definite results on this head. We have, however, generally found it considerably below the average during pregnancy.

SECT. III.—Of the Saponaceous Matters.

(Oleate, Margarate, and Stearate of Soda.)

This saponified compound, as found in the serum of the blood, presents certain characteristics which are always identical, and its variations, as in the case of the cholesterine, are under the influence of comparatively fixed laws.

In health, the mean amount of this substance is about 1.00 for every 1000 parts of blood, its maximum and minimum of variation ranging from 0.700 to 2.00.

The changes which it undergoes in disease are, in general, similar to those of the cholesterine, although somewhat less constant. Thus we have found it increased—1. In acute febrile affections; 2. In acute inflammations; 3. In jaundice with retention of bile.

The study of its decrease leads to no positive fact susceptible of general application.

SECT. IV.—Of the Phosphuretted Fatty Matter.

We have investigated with the utmost care, the composition of the fatty matters of the blood when removed from the serum, and have been much assisted in our researches by an able chemist, M. Cahours.

His experiments relative to the seroline, the cholesterine and the animal soap existing in the blood, do not appear to have produced any definite results, while the specimens of these substances which we have forwarded to him, have served to demonstrate their perfect purity.

With regard to that substance which has been designated as the *phosphuretted fatty matter* of the blood, although produced under similar circumstances, and possessing similar external characteristics, it is a most complex compound.

The following *resumé* respecting it is given by M. Cahours: Its reaction is slightly alkaline: it contains—1. Chloride of sodium; 2. A fatty matter, partly saponified by means of soda; 3. A non-saponified fatty matter. This last is partially soluble in a solution of potash, and leaves behind a brownish extractive. The potash soap, when decomposed by an acid, deposits an oil (oleic acid) and a solid residuum (margaric acid).

Influenced by these results, we no longer consider it necessary to attach importance to the consequences previously deduced from the measurement of this supposed phosphuretted fatty matter. We find it, in fact, to be composed of soda soap, mixed with a small proportion of non-saponifiable fat, and chloride of sodium.

ARTICLE VI.

OF THE INORGANIC SALTS CONTAINED IN THE BLOOD.

The salts contained in the blood are numerous. Some, existing in comparatively large quantities, play an important part; others are found in such small proportion, that, without denying their influence, we must admit that their quantitative variations have not as yet been investigated.

We shall examine in succession:

a. The chloride of sodium;

b. The carbonate of soda;

c. The phosphate of lime; and, as an appendix to the study of the salts, we shall speak of the iron.

SECT. I.—Of the Chloride of Sodium.

To obtain the chloride of sodium, together with the other salts of the blood, it is of the utmost importance to effect the incineration of this fluid, and then to analyse the residuum. During the process, however, it is scarcely possible to prevent a small quantity of the chloride from being volatilized, and its relative proportion thus becomes somewhat diminished. This loss cannot be obviated, and may even be disregarded, since, the process being invariably the same, the loss is so likewise; in other words, it is always proportionate to the amount of chloride of sodium existing in the blood.

We must here observe, that under the term chloride of sodium, we comprehend a minute quantity of chloride of potassium and magnesium with which it is mixed.

This reservation being made, we may proceed to examine the normal proportions of the chloride of sodium, and the chief modifications of which it is susceptible.

The average amount of this salt contained in healthy blood, may be estimated at 3.5 per 1000: a large proportion, exceeding as it does that of the fibrin. It is evident, therefore, that a salt existing to such an extent in the blood, must play an important part in the nutrition of the organism. The numbers 3.5 represent merely the mean proportion, which may vary, however, within tolerably wide limits, the maximum and minimum being 4.5 and 2.5.

The numbers given by Lehmann and Nasse confirm our own results. Thus, according to Lehmann, in 100 parts of healthy blood, the mean proportion of chloride of sodium is 4.21, and according to Nasse, from 4.05 to 4.60.

An increase of this salt in the blood is a somewhat rare and exceptional occurrence. We are unable to state precisely the circumstances under which it may take place, but must content ourselves with saying, that in the blood of cholera patients, we have found the proportion of chloride of sodium to be above the standard of health.

On the other hand, it invariably decreases under the influence of low diet. Thus, in acute disease generally, we have found, as the results of numerous and varied experiments, a mean proportion of 2.5, varying from 2.0 to 3.0 as the minimum and maximum. These numbers show the decrease of this salt to be considerable; and it is evidently due to want of nourishment, and to the interrupted supply of chloride of sodium to the system at large.

We know of no other fact of importance, in connexion with the chloride of sodium, beyond this: that in the phlegmasiæ, the proportion of this salt is, on the average, even somewhat less than in acute diseases generally, when treated by low diet, etc.

The researches of M. Mialhé have fully confirmed our own, and have established the decrease of the chloride of sodium in disease generally.

SECT. II.—Of the Carbonate of Soda.

On analyzing the ashes left by the incineration of a portion of blood, we immediately find the necessity of distinguishing between two portions of the residuum, one of which is soluble, the other insoluble.

The soluble portion contains—1. The chlorides: these we have considered in the preceding section; 2. Another portion, containing certain other soluble salts apart from the chlorides. These salts are the following: 1. Carbonate of soda, which constitutes the major portion; 2. A small quantity of free soda; 3. A small quantity of sulphate and phosphate of soda; lastly, a trace of carbonate, phosphate, and sulphate of potash, and of sulphate of magnesia. These salts, so far as their proportions relative to the salts of soda are concerned, may be disregarded.

This portion of the soluble residuum left by incineration of the blood, may, without fear of error, be designated as *soluble salts of soda, minus chloride of sodium;* or, perhaps, as accurately by the term *carbonate of soda.*

Retaining, however, the first denomination, we shall examine, in a general way, the variations which these soluble salts of soda may undergo.

Their mean amount may be represented by 2.5, and their variations are more limited than those of the chloride of sodium; their maximum and minimum may be stated at 3.0 and 2.0.

The researches of Lehmann corroborate the above statements, for he finds a mean proportion of 1.628 of carbonate of soda in 1000 parts of human blood. It is very probable, therefore, that as, in our experiments, 2.500 was found to represent the soluble salts of soda in the aggregate, the numbers 1.628 would express the amount of the carbonate of soda taken singly.

The soluble salts of soda may be diminished in certain diseases. Thus we find from repeated analysis, that the mean amount of the soluble salts is less in the phlegmasiæ than in health. It may be represented by 2.00.

The increase of the salts of soda is rather admitted by induction and theory, than demonstrated with certainty. M. Fremy, however, having on one occasion examined the blood of an individual suffering from scurvy, found the proportion of alkaline salts to be increased. MM. Andral and Gavarret arrived at the same results in a similar case. (*Hemat.*, p. 138.)

Sect. III.—Of the Phosphate of Lime.

The phosphate of lime is always found in combination with a small quantity of equally insoluble phosphate of magnesia.

The mean proportion is 0.350 in 1000 parts of blood; the limits of variation being 0.400 and 0.300.

The variations which this salt undergoes in disease are of considerable importance: and we might almost say, that few of the elementary principles of the blood are so much influenced by it as is the phosphate of lime.

Increase of the Phosphate of Lime.—It is a remarkable fact, that the physiological condition is that in which the proportion of phosphate of lime is the smallest; whilst in the majority of diseases it is almost invariably increased, as shewn in the following table:

Anæmia	0.545
Pulmonary tuberculosis, first bleeding	0.493
Ditto ditto second bleeding	0.475
Ditto ditto third bleeding	0.362
Typhoid fever	0.497
Pregnancy	0.425
Chlorosis	0.441

In other cases, the departure from the healthy standard is but slight.

Plethora	0.341

This may easily be conceived, inasmuch as there is no absolute alteration of the blood in plethora, but merely a modification in point of quantity.

In the phlegmasiæ	0.396

This may almost be regarded as a marked increase, when contrasted with the standard of health.

ARTICLE VII.

OF THE IRON.

The question as to the actual form in which the iron exists in the blood, is considered by chemists as not yet admitting of a definite answer. Without entering upon a discussion which would be foreign to the subject, we shall content ourselves with stating: 1. That the iron exists in the globules, of which it forms one of the constituent parts or inorganic elements; 2. That not a trace of it is to be found either in the serum or in the fibrin; 3. That its quantity varies directly in proportion to the amount of globules contained in the blood.

These propositions are based upon a considerable number of analyses, the accuracy of which can scarcely be contested.

It would seem, therefore, almost superfluous to state here, the weight of the iron. For the sake of completeness, however, we may quote the following:

Mean proportion in health	0.550
Maximum in health	0.600
Minimum in ditto	0.500

An increase of the iron is, like that of the globules, a rare and exceptional occurrence. A decrease, on the other hand, is very common, and occurs under the following circumstances:

In pregnancy	0.449
„ the phlegmasiæ generally	0.480
„ phthisis, first bleeding	0.489
„ ditto second bleeding	0.482
„ ditto third bleeding	0.442
„ Anæmia	0.366
„ Chlorosis	0.319

ARTICLE VIII.

OF CERTAIN FOREIGN MATTERS OCCASIONALLY FOUND IN THE BLOOD.

Biliary pigments (bilious serum);
Fatty matters (milky serum);
Urea;
Sugar;
Pus;
Entozoa;
Cancerous matter;
Tubercular matter.

SECT. I.—Of the Bile Pigment.

It is now about twenty years, since some lively discussions arose between chemists and pathologists relative to the following questions. Can the bile pass into the blood? or can the bile be developed in the blood? Amid the conflict of opinions, that which denied to the bile the possibility of such an occurrence, was very generally admitted. At the present epoch, a similar discussion would afford but little interest, and the solution of the question may be arrived at in a very simple manner.

What is bile? If we admit the exact analysis made of this substance by M. Demarçay,—and we are inclined to do so,—we should say, that the bile is a fluid, holding in solution, choleate of soda, margarate, oleate, and stearate of soda, cholesterine, and one, if not two, biliary pigments.

When, therefore, we ask, if bile can exist in the blood, and understand, by such a question, the bile in its perfect state, we answer no, it is not fully formed bile that exists in the blood.

If, however, by bile in the blood we mean the principal constituents of this fluid, then without doubt such an occurrence may take place, and we frequently even find a serum which might in some sort be termed bilious.

The following component parts of the bile are found in the blood, and may, under certain circumstances, of which we shall presently speak, accumulate in the serum, where they are consequently met with in much larger proportion than in health:

1. Cholesterine;

2. Animal soap, *i.e.* the compound formed by the oleates, margarates, and stearates of soda.

These principles accumulate in the blood; 1. When there is an obstacle to the free flow of bile, with jaundice and pale evacuations; 2. When, from some general predisposition, the nature of which is often latent, but which is itself frequently the result of a moist warm temperature, there has been developed, what is commonly called a bilious state of the system. The bile appears in such cases to be more abundantly secreted by the liver; it flows into the intestines, and at the same time the skin becomes jaundiced.

In both these cases, while the cholesterine and soda in combination with the fatty acids are accumulating in the blood, there is almost always, without exception, an appearance of bile-pigments in the serum. These pigments are, as we shall show hereafter, of two kinds; the yellow (the *bilifulvin* of Berzelius) and the green pigment (the *biliverdin* of the same chemist).

It is easy to demonstrate the presence of biliary pigment in the serum of the blood. In the majority of instances, inspection alone, or the immersion of a piece of white cloth into the fluid, will serve to shew its yellowish green tinge. If any doubt remain, the process recommended by M. Martin Solon may be adopted; it consists in separating the serum from the clot, and treating the former with nitric acid. The albumen coagulates, but instead of being of a pure white colour, as is generally the case, it presents a greenish tinge, the depth of which varies with the quantity of bile-pigment contained in the serum of the blood.

To sum up then, we may state, that the component parts of the bile, with the exception of the choleate of soda, may accumulate in the serum of the blood, when the flow of bile is arrested, or its secretion greatly increased.

Sect. II.—Of the Fatty Matters (Milky Serum).

A peculiar species of serum is occasionally met with, to which the term *milky serum* has been applied.

Endeavours have been made to ascertain precisely the circumstances in which it is met with, and the subjoined facts have been established.

1. During the process of digestion, the lactescence of the serum begins, in general, two hours after the ingestion of aliment, and continues for the space of two or three hours. The serum is found to be turbid, opalescent and semi-opaque; this condition is altogether transitory: it is due to the absorption of the fatty matters of the food, formed into an emulsion by the pancreatic juice, and absorbed as such in the duodenum. A microscopic examination discloses—1. A large number of fat globules; 2. molecular granules of an albuminous or fibrino-albuminous nature. In a word, it is the passage of the chyle into the blood which renders the serum turbid, and continues to do so, until these fatty matters, which according to the researches of Christison and Lecanu, are merely the insoluble oleine, stearine and margarine, become converted into fatty acids; the oleic, stearic, and margaric acids, which entering into combination with the free soda of the blood, thus cause the disappearance of the fat globules.

With regard to the molecular granules, it is probable that they are destined to be transformed into blood globules.

2. In disease, the serum has occasionally been found in a lactescent state. This phenomenon is, however, entirely different from that which we have just considered. We shall

examine successively—A. The nature of the alteration constituting lactescence of the serum; B. The morbid conditions in which it is occasionally met with.

A. *Nature of the lactescence.* This appearance may be due to one or other of two essentially different causes. The first consists in the presence of non-saponified fatty matters in the serum, viz., the oleine, margarine and stearine; as is most frequently the case. According to the researches of Marcet, Trail, Zanarelli, Christison, Lecanu, Lassaigne and Bertazzi, the turbidity of the serum in cases of disease is always owing to the presence of non-saponified fatty matters. The proportion of fat existing in the blood is very variable; on one occasion M. Lecanu found 117 grammes in 1000. In a similar quantity, Trail found 45, and Bertazzi only 6.

We have on three occasions met with lactescent serum; once in a case of pneumonia, and twice in Bright's disease. In the former, we found under the microscope, a combination of fat globules and albuminous granules. In the latter, we merely detected the granules, nor did a subsequent analysis demonstrate an excess of fatty matter.

B. *Cases in which lactescent serum is met with.* On this point we possess no definite information. It is reported, however, to have been met with in the following cases: in diabetes (Marcet); in dropsy, jaundice and nephritis (Christison); in hepatitis (Trail); in pneumonia (Zanarelli); in a case of mammary abscess (Simon). It certainly, however, occurs most frequently in Bright's disease. (Gregory, Christison, Rayer, Becquerel, Rodier, etc.)

Lastly, it has been found in certain healthy individuals. We conceive however that in these cases, there must have been some error, and that the lactescence produced by digestion has been mistaken for that resulting from disease.

SECT. III.—Of the Urea.

Urea probably exists in healthy blood, but in too small a quantity to be discovered by chemical analysis. Certain physiological experiments have however established the fact; for having extirpated the kidneys of animals, M. Prevost and Dumas showed that the urea, being no longer eliminated by those organs, accumulated in the blood and could be detected there with the utmost ease.

Analogy therefore admits the supposition that, whenever the function of the kidneys is either impaired or gradually suppressed, a similar phenomenon may occur. Thus it was, that the presence of urea in the blood of persons suffering from Bright's disease, became a generally received opinion, before direct experiment had proved the fact.

It is chiefly in Great Britain, that this principle has been found in the blood by Bostock, Gregory, Christison. It has been noticed in France likewise, by Rayer Guibourt and other experimentalists.

Having, about twelve years ago, in conjunction with M. Quevenne, made some experiments tending in this direction, we failed to detect urea in the blood. But as positive facts are not to be destroyed by merely negative ones, we must consider it proved, that in the majority of cases of Bright's disease, the urea not being secreted by the kidneys in proper quantity, accumulates in the blood, where it may be discovered by analysis.

Does the same thing occur, however, when, from any other cause, the urinary secretion is greatly diminished, as in retention of urine, and in the various diseases to which the kidney is liable? On this subject, analysis is as yet silent; and here, as in Bright's disease, much remains yet to be done.

Again, what consequences result from the presence of urea in the blood? This is another question, to which we can as yet give no satisfactory answer. It has indeed been asserted that when the accumulation became considerable, we might attribute to it, those cerebral symptoms which are commonly met with in the last stage of many renal diseases; this may possibly be the case, but it altogether remains to be proved.

There are two processes by which the urea may be removed from the blood. The following is that recommended by M. Verdeil in his treatise on chemistry (*Robin et Verdeil*).

"The defibrinized blood is to be coagulated with an equal "weight of water, filtered through a cloth, and evaporated in a "water bath. The fluid, reduced to the consistence of a "syrup, is then mixed with alcohol; this causes a precipitate "which is to be removed. The alcoholic solution is now evaporated and treated with oxalic acid, which decomposes the "soap and renders the fatty matters insoluble. Æther is then "added to the filtered fluid, this dissolves all the hippuric acid, "and forms a superficial pellicle which may be removed: the "subjacent portion, having been neutralized by the addition of "carbonate of lime, is again evaporated, and dried *in vacuo.* "The dried mass is then treated with pure cold alcohol; this "almost entirely dissolves the urea, which may be then obtained, either in crystals or in combination with the nitric "and oxalic acids."

By means of this process, say MM. Robin and Verdeil, Dr. Hervier was enabled to detect the habitual presence of urea in human blood, when experimenting upon 250 or 300 grammes (9⅜ oz.) of this fluid.*

SECT. IV.—Of the Sugar.

Sugar exists naturally in certain portions of the circulating system. We have seen, in fact, that after being secreted by the liver, it passes into the hepatic veins, the inferior vena cava, the right cavities of the heart, the pulmonary artery, and from thence into the lungs, where it is consumed. In no other part of the circulating apparatus do we find it during health.

The only disease in which it has been found, is diabetes; and in this, its presence has given rise to so much difference of opinion, that doubts remain in the minds of many respecting it.

It is certainly, however, found in no other disease: among the thousands of specimens of serum which we have examined, it has never once been detected, nor has any other chemist alluded to its presence, except in cases of diabetes.

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* *Chimie anatomique et physiologique, normale et pathologique.* 1853. Vol. ii, p. 516.

But even in this disease, its existence in the blood has, as we have seen, been considered doubtful, and is even denied by some chemists (Guendeville, Vanquelin, Segalas, Wollaston, and Henry). The interesting researches of M. Bouchardat have, in a measure, reconciled these differences of opinion.

According to this writer, there exists in the serum of the blood of many diabetic patients, a certain amount of glucose, the detection of which is easy. In others, it occurs only during the process of digestion; so that, if venesection is practised after the performance of this function, no glucose is met with.

To ascertain the presence of sugar, we may have recourse to a polarizing apparatus, or to certain chemical tests.

Polarization of light.—The albumen of the serum deviates a ray of polarized light to the left; the glucose has a reverse effect. Should there be, therefore, a quantity of this substance existing in the blood, equivalent to 70 or 100 parts per 1000, the deviation to the right, as produced by the glucose, being about equal to that produced by the albumen to the left, no effect will take place. If, on the other hand, the quantity of glucose exceed 100 parts per 1000, there will be visible deviation to the right. Lastly, if the quantity fall below 60 parts, the sinistral deviation will be less than usual, but at least sufficient to attract the observer's attention, and to induce him to seek the presence of sugar by some other process. It is as the result of upwards of a thousand analyses of the blood, by means of the polarimeter, that we feel authorized to affirm, that if sugar exists in the blood of persons suffering from other diseases than diabetes, the fact is extremely rare and exceptional.

The chemical processes employed to ascertain the presence of sugar, are almost exclusively restricted to the following:

1. *The solution of Barreswill*, the formula of which is as follows:

Carbonate of soda (in crystals)	40 parts
Supertartrate of potash	50 „
Caustic potash	40 „
Distilled water	400 „

Make a solution, and add the following:

Sulphate of copper	30 „
Water	100 „

Mix, and filter the two solutions when mixed.

This solution, when added to a liquid containing glucose, and heated, gives a reddish precipitate of reduced copper. In this case, an albuminous deposit, coloured by the copper, is produced.

2. *Caustic potash.*—A fragment of caustic potash, added to serum containing glucose, gives an albuminous precipitate, of a brownish colour, due to the combination of albumen with ulmate of potash. This ulmic acid is formed by a transformation which the glucose undergoes in presence of caustic potash.

The existence of sugar in the blood does not appear to influence the other component elements of this fluid.

SECT. V.—PUS.

The presence of pus in the blood is a question upon which a vast amount of controversy has arisen; nor, indeed, has it been yet satisfactorily settled. We shall endeavour, however, to state what is actually known respecting it, and to suggest a few problems, the solution of which would be of importance.

1st query. *Can pus exist in the blood?*

To answer this question, we must, as when speaking of bile in the blood, understand what is meant by this so-called *presence of pus in the blood.* Does it imply that actual pus may be found in the blood, with all its component elements? This it is impossible to demonstrate, and for the following reason: the majority of the substances constituting pus, are found in healthy blood, as, for instance, water, albumen, cholesterine, fatty acids, and the salts of soda, especially the chloride of sodium. How, then, are we to determine what belongs to the pus and what to the blood? As there is usually but a small quantity of pus in the blood, no conclusion can be drawn from the increased proportion of those chemical elements which it contains in health. One element, however, remains, which may be regarded as the characteristic feature of true pus,—namely, the pus globule. The whole problem may therefore be expressed thus: *Have the pus globules been found in the blood?* We answer, Yes, in all probability.

If blood and pus be mixed together artificially, and then examined under the microscope, the blood and pus globules are found mingled together, each preserving its peculiar characteristics, which we need not here recapitulate. We must, however, observe, that the pus globules bear so marked a similarity to the large white globules of the blood, that they are constantly mistaken the one for the other. In the present instance, however, being made aware of the combination, the eye is not so likely to be deceived; but in those cases where a small number of pus globules exist in the blood, the difficulty becomes very great, and, in spite of experience, we believe it impossible to decide whether the suspected globules belong to the pus or to the blood.

M. Donné has suggested a very ingenious process: it consists in placing, in the field of the microscope, a drop of blood, in contact with a drop of ammonia, which causes the red and white globules to dissolve almost instantaneously. If, on the contrary, we place a drop of pus in contact with a drop of ammonia, the pus globules, it is true, undergo solution, but the process is much slower and less complete. Upon this distinction does M. Donné found the diagnosis of pus. The process is ingenious, though uncertain, as affording no positive characteristic, but constituting merely a question of degree; moreover, it may happen that some of the blood globules dissolve more slowly in the ammonia than the pus globules, and hence another source of error.

In conclusion, we may state, that the existence of pus globules in the blood is very probable, if not certain; but that positive demonstration of the fact is extremely difficult.

2nd query. *Whence comes the pus; or, rather, from whence are the pus globules, found in the blood, derived?*

Three opinions have been emitted, as offering a solution of this problem, each of which possesses certain claims to support.

A. *The pus globules are absorbed from a suppurating cavity.*—To this theory the term *purulent absorption* has been given, and it is still received by many authorities. The following arguments have been adduced in its favour—viz., that the general condition characteristic of purulent absorption, is always found in connexion with a suppurating organ or wound, and that the pus formed by such wound, diminishes in proportion as the general phenomena become fully developed.

In opposition to this theory, the following objections have been urged—viz., 1. That the capillary vessels are, for the most part, of too small calibre to admit the pus globules; 2. That the presence of pus globules in the blood has the effect of producing immediate coagulation of the surrounding fibrin, which acts thus as a barrier to the further advance of the pus; 3. That this coagulation occurs in the immediate vicinity of the suppurating locality; and lastly, that there are cases occasionally to be met with, in which the general symptoms constituting what has been termed purulent fever, etc., etc., exist, without the slightest trace of actual suppuration. The difficulty of giving a decisive opinion, in presence of such conflicting arguments, is obvious.

B. *The pus is the result of phlebitis, occurring in the veins which are in contact with the suppurating tissues.*—The following arguments favour this supposition: in the great majority of cases, we find actual traces of phlebitis, of which, however, there are two kinds—adhesive phlebitis, when its object appears to be, to cause adhesion of the walls of those veins which have remained pervious; and suppurative phlebitis, when it merely produces pus.

Against the doctrine of phlebitis, the same arguments have been brought forward as in the case of purulent absorption—viz., that the contact of the pus globules with the blood, produces instant coagulation of this latter fluid. This uncontrovertible fact has been explained away by the partizans of phlebitis. True, say they, the pus at first produces coagulation of the blood with which it comes in contact, and is thus prevented from doing further mischief, and this probably occurs in the great majority of cases; but there are others, in which the pus, continuously secreted by the wall of the inflamed vein, at length breaks down the obstacle presented by the recently-formed coagulum, and is forthwith carried into the circulation.

c. *The pus is furnished by the blood itself.*—In other words, the blood undergoes a transformation, in virtue of a peculiar morbid general condition of the system, to which the term *purulent diathesis* has been given, and from whence results the spontaneous formation of pus. In a word, this theory supposes the blood to suppurate in the same manner as do the solid tissues.

According to this theory, which is due to M. Tessier, the very frequent occurrence of phlebitis in diseased organs and in wounds (the results of amputation, injuries, parturition, etc.), is explained, upon the supposition that the blood suppurates, and deposits its morbid products, by preference, in those parts which are already inflamed and diseased.

In presence of the above theories, it is no easy matter to form an exact idea of the question at issue. We conceive it possible, however, that each may be true, and that the presence of pus in the blood may be of three-fold origin: purulent absorption, phlebitis, and spontaneous suppuration.

3rd query. *What are the consequences resulting from the presence of pus globules in the blood?*

They are two-fold,—physical and pathological.

A. *Physical consequences resulting from the presence of pus in the blood.*—Of these, the most important is a diminished coagulability of the latter fluid. To prove this, recourse has been had to direct examination and experiment; and few are ignorant of that made by M. Donné, who found that the coagulation of freshly drawn blood was prevented by its admixture with a certain amount of pus. The experiment, however, is not of much value. In the first place, it does not always succeed, as was the case with two most able observers, MM. Andral and Gavarret; and again, we cannot conclude, from what takes place when a considerable quantity of pus is added to blood, that similar phenomena must likewise result from the admixture of a very small proportion of this material; and, in fact, the quantity of pus existing in the blood is always very small, in proportion to the entire mass of that fluid. The question is, therefore, more easily solved by direct observation of the blood itself; for the majority of competent authorities agree in admitting, that in fatal cases of the purulent diathesis, the blood is more fluid and less coagulable than usual. It is very probable, therefore, that this condition does actually result from the admixture of pus with the blood. It is not, however, thoroughly proved to do so, as yet.

B. *Pathological consequences resulting from the presence of pus in the blood.*—These are of two kinds,—general and local.

Local phenomena.—Under this head, we may class the so-called metastatic abscesses, or purulent phlegmasiæ. These abscesses, which we cannot here attempt to describe, occur for the most part in the lungs and liver. It is not uncommon, however, to find them in many other localities, such as the spleen, the kidneys, the brain, the muscles, etc.

It may be asked, whence the formation of these abscesses? and here we meet with three hypotheses, each bearing reference to one or other of those theories upon which the entrance of pus into the blood has been explained. Thus, some believe (as we have already seen) that the pus absorbed from a suppurating locality is deposited, as such, in the parenchymatous tissues; others, that a recurrence of the phlebitis, which first gave rise to the pus, takes place in these same tissues; such metastatic abscesses being regarded as so many small local parenchymatous phlebites. Lastly, those who advocate the theory of a purulent diathesis, consider these abscesses as simply resulting from it; and this may easily be conceived from their own definition of the purulent diathesis, viz.: A general proneness, on the part of the blood and the organs in general, to inflammation and suppuration. We shall not here enter into this discussion, our object being simply to state the actual condition of science, on this head.

The purulent phlegmasiæ may be defined as, inflammations occurring with the utmost facility in individuals whose blood contains pus globules. They are especially characterized by their rapid progress, and by arriving at the suppurative stage more rapidly and easily, than under any other circumstances.

General Phenomena.—The general symptoms resulting from the presence of pus in the blood, constitute what has been termed purulent fever, the fever of absorption. It presents the following characteristics: a febrile condition, generally accompanied by rigor, and often by a nocturnal exacerbation; this is often mistaken for intermittent fever. It is attended with rapid emaciation, and a peculiar change in the countenance, which assumes, as does the cutaneous surface generally, a pale yellow, earthy tinge, sometimes resembling jaundice. The strength fails rapidly, there is often slight delirium, and death is almost inevitable. Such are the general features of this morbid condition, of which we can here give but an outline.

Sect. VI.—Entozoa of the Blood.

Chiaje, of Naples, has noticed the presence of the *Polystoma sanguiculum* in blood expectorated by two phthisical individuals: they are small flattened worms, resembling minute floating leeches. He describes them thus: "Corpus teretiusculum seu depressum, pori sex antici ventrales, et posticus solitarius. Habitat in venoso systemate hominis, et præsertim in ejusdem pulmonali parenchymate."

Goodfellow has observed an immense number of animalculi, in the blood of an individual suffering from fever. They varied in length from $\frac{1}{3000}$th to the $\frac{1}{5000}$th of an inch. Their diameter, which was the same in every part, varied from the $\frac{1}{20000}$th to the $\frac{1}{40000}$th of an inch.

Bushnan has also noticed the remarkable case of a young man affected with influenza, and in whose blood he found worms half-an-inch long.

MM. Gruby and Delafond have demonstrated the frequent existence of a species of thread worm in the blood of the dog; they have not, however, found it in man.

It is evident, therefore, from the paucity of documents which we possess, that the history of the animalcules of the blood in man remains yet to be written.

SECT. VII.—Tubercular Matter.

Can the tubercular corpuscles be absorbed and pass into the blood? This question we feel disposed to answer in the negative, and for the following reason: that the property of tubercular matter is to cause the obliteration of those vessels with which it comes in contact. This fact has been demonstrated in the most unequivocal manner, by the experiments of Van der Kolk and M. Natalis Guillot, and hence we may understand the impossibility of the tubercular corpuscles being absorbed. The fact of their giving rise, in certain cases, to the formation of caverns and the rupture of vessels proves nothing. It is no longer the tubercular matter which alone acts, but the ulceration of tissue to which it gives rise.

The tubercular corpuscles are not distinct, clearly defined bodies; and if it be difficult to distinguish them when examining a mass of tubercular matter, it may readily be understood how far more difficult it must be to recognize them, when disseminated in small numbers through the entire mass of the blood.

It is, however, by no means necessary to presuppose the existence of these bodies in the blood, in order to explain the process of tuberculization. The disease is, in the vast majority of cases, a local one (?), and the deterioration of constitution which accompanies it, is due to suppuration, to the gradual extension of the disease, and to the decrease of the albumen and globules, as well as of the mass of the blood itself.

SECT. VIII.—Cancerous Matter.

The relation which the peculiar matter of cancer bears to the blood, is very different from that of tubercular matter. Cancer, in fact, is a disease which, when it has reached a certain stage, has a tendency to become general, and to reproduce itself in various parts of the organism. Moreover, cancer far from possessing, like tubercle, the property of obliterating the vascular canals lying in its vicinity, invades them with the utmost facility, penetrates, and finally destroys them. We may, therefore, admit, to a certain extent *à priori*, the presence of cancer cells in the blood of individuals labouring under that condition of the system termed the *cancerous diathesis.*

Long previous to the employment of the microscope for the purpose of detecting the presence of cancerous matter in the blood, the fact had been admitted as the result of direct observation. In 1817, Langstaff found cancerous matter in the veins. In 1824, M. Velpeau met with encephaloid cancer in the vena cava and iliac veins of an individual affected with cancer of the testicle. MM. Andral, Cruveilhier, and Gintrac, have found cancerous matter in the different veins receiving blood from organs affected with cancer; while lately, as a corollary to these researches, microscopists have pointed out the presence of the cancer cell in the blood of persons presenting the characteristic marks of the cancerous diathesis.*

Much research is, however, yet requisite to prove that the presence of the cancer cell in the blood is the real cause of the dissemination of cancer throughout the different organs of the body and of the peculiar cachexy by which it is accompanied.

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* Vide Lebert, *Traité des Maladies cancereuses.*

SECTION V.

OF THE COMPOSITION OF THE BLOOD, PHYSIOLOGICALLY CONSIDERED.

It is somewhat difficult to give a general formula which shall represent the composition of the blood in health. A thousand influences may modify its composition, and these modifications, although restricted within narrow limits, do not the less differ from the standard formula.

To understand the variations of which the composition of the blood is susceptible in health, it is necessary, however, that we should give this formula.

MM. Prevost and Dumas were the first to ascertain the mean composition of the blood. Their researches shew, that in 1000 parts of blood there are 127 parts of globules, 3 of fibrin, 80 of solid matters of the serum, and 790 of water. This formula, modified first by M. Denis and then by M. Lecanu, was that, nevertheless, adopted by MM. Andral and Gavarret, and it served as a starting point for establishing the general principles upon which the modifications of the blood depend.

From our own researches, we have deduced the following formula, which we here give in round numbers:

Analysis of 1000 *grammes of blood.*

Specific gravity of the blood	1060.00
Water	781.60
Globules	135.00
Albumen	70.00
Fibrin	2.50
Fatty matters, extractive matters, and free salts	10.00
Phosphates	0.55
Iron	0.35

Analysis of 1000 *grammes of serum.*

Specific gravity of the serum	1028.00
Water	908.00
Albumen	80.00
Extractive and fatty matters, free salts	12.00

Analysis of 10 *grammes of fatty matters, extractive matters, and free salts.*

		FATTY MATTERS.	
Total	1.550	Seroline	0.025
		Cholesterine	0.125
		Soap	1.400
		FREE SALTS.	
Total	6.00	Chloride of sodium	3.5
		Soluble salts of soda	2.5
Extractive matters, undetermined			2.450

In order to arrive at the above formula, we have analysed the blood of twenty-two healthy persons, and we would refer the reader to our special researches on the blood, in which work he will find a full account of the process employed in the analysis of this fluid.*

ARTICLE I.

OF THE DIFFERENCES IN THE BLOOD OF THE VARIOUS PARTS OF THE SYSTEM.

SECT. I.—Of the Difference between the Arterial and Venous Blood.

We possess no comparative analysis of the arterial and venous blood in man. To make such analysis, it would be necessary to take advantage of certain accidents, such as hæmorrhage from the larger arteries, etc., and this has not as yet been done. A few analyses only have been made upon the blood of horses, and these have but led to results of a somewhat contradictory character.

Simon, having made two comparative experiments upon the blood obtained from the carotid artery and jugular vein of a horse, arrived at the following conclusions:

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* *Recherches sur la composition du sang dans l'état de santé et dans l'état de maladie.* Par A. Becquerel et A. Rodier. Chez Victor Masson, à Paris.

The arterial blood contains less solid residuum than the venous blood. There is less fatty matter, fewer globules, less albumen, and a smaller proportion of extractive matter and salts; the globules, moreover, contain less colouring matter. As for the fibrin, it remains the same.

Denis, Hertwig, and Schultz, have arrived at very similar results.

Prevost, Dumas, and Lecanu, however, have adopted different conclusions.

Müller and Berthold found a larger proportion of fibrin in arterial than in venous blood.

Simon, likewise, made an experiment upon the blood of the aorta and renal vein of a horse, and found that the blood of the latter contained more albumen and solid constituents than that of the former, but that it was less rich in fibrin and globules.

Finally, we are indebted to M. Béclard for three comparative analyses of the blood of the carotid artery and jugular vein of a horse and two dogs. From these it would appear, that the venous blood is more watery, and contains less albumen and globules than the arterial blood. As for the fibrin, its proportions do not appear to vary: a slight increase, however, may perhaps exist.

From the limited number of analyses of which we have here given an outline, we may conclude that there is an actual difference between the two kinds of blood, since it is evident that the arterial blood, while circulating through different organs, must undergo certain losses. But if, on the other hand, we consider that to repair such losses, the venous blood receives the products of absorption of the lymphatics and lacteals, it may be presumed that the latter recovers a portion of what it had lost. The later researches, however, of M. Béclard, seem to shew that the loss is not so compensated for, as to render the venous blood as rich as the arterial.

SECT. II.—Of the Differences in the Venous Blood in different parts of the Circulatory System.

The solution of this problem is beset with numerous difficulties.

To obtain results admitting of comparison, it would be requisite to analyse human blood drawn simultaneously from different parts of the venous system. This, however, is impossible.

In animals, the necessity of withdrawing a large quantity of blood from various parts of the venous system, annihilates beforehand all accuracy in the results, since, as we have before stated, the blood which escapes is replaced by a rapid absorption of water on the part of the venous system. With regard to arterial blood, the problem is alike unsolved.

The following conclusions, however, have been arrived at by M. Béclard. They may serve, in a measure, to elucidate the question:

". . . . . . 4. The venous blood is the same in every part of the venous system.

"5. The venous blood coming from the spleen, always contains fewer globules than venous blood in general.

"6. The venous blood coming from the spleen, contains more albumen than venous blood in general.

"7. It also contains more fibrin.

"8. The blood of the vena porta presents remarkable variations in the proportion of its constituents, and these variations have reference to the phenomena of digestion.

"A. During the first period of digestive absorption, the quantity of albumen is much increased, while the globules are much diminished.

"B. Subsequent to this process, the globules are much increased and the albumen diminished.

"9. The transformation of the albumen into blood globules takes place in the portal system.

"10. The blood globules are destroyed in the spleen.

"11. While the intestinal branch of the portal vein conveys the newly formed globules into the common trunk, the splenic branch transmits thither, the remains of those which have been disintegrated in the spleen.

"12. The neutral nitrogenized matters enter the blood in one and the same form, viz., that of albumen.

"13. The vena porta appears to be the sole channel by which the albuminous matters enter the blood.

"14. The blood of the vena porta does not contain a larger proportion of fatty matters than venous blood in general."

We are indebted to M. C. Bernard for some interesting researches relative to the venous blood. Unfortunately, he has omitted all quantitative analyses, which would otherwise have rendered his valuable discoveries almost perfect.

According to M. Bernard, the liver forms sugar, fibrin, and fat.

Sugar was not found in the vena porta; but, on the other hand, it was discovered in the liver and hepatic veins. This fact is incontestable, and constitutes one of the most remarkable of modern physiological discoveries. M. Bernard asserts, moreover, that a larger proportion of fibrin and fatty matter is found in the hepatic veins than in the vena porta; unfortunately, he brings forward no quantitative analyses in support of this statement, and here they are indispensable.

A comparative analysis of the blood of the vena porta and hepatic veins has been made by Simon, with a view of throwing light upon the functions of the liver.

According to Gurth, the blood of the hepatic veins contains less fibrin, fat, globules, extractive matter, and salts, than the blood of the vena porta. These conclusions are deduced from quantitative analysis, and are directly at variance with those of M. Bernard.

Of the blood in the capillaries.—This has been analysed by Pallas, and found to contain a larger proportion of solid and coagulable elements than either arterial or venous blood.

The experiments of Denis do not appear to confirm those of Pallas.

Of menstrual blood.—We know of but two analyses of menstrual blood. The one is due to Denis, the other to Simon.

That of Simon gave the following results:

Water	785.00
Solid matters	215.00
Fat	2.58
Albumen	76.54
Globules	120.40
Extractive matter and salts	8.60

From this it would appear that, menstrual blood differs but little from that of health.

ARTICLE II.

OF THE INFLUENCE OF SEX ON THE COMPOSITION OF THE BLOOD.

M. Denis was one of the first to draw attention to the difference which exists between the blood of the male and female. At a later period, the researches of M. Lecanu served to throw some light upon the subject, and the following are the conclusions at which we ourselves have arrived, as the result of experiment.

In man, the blood contains less water than in woman;

It contains a larger proportion of globules;

Its specific gravity is higher.

The proportion of fibrin and albumen is the same in both.

That of the fatty matters and salts is also identical.

The following table indicates the chief differences which exist between the male and female of the human species, with reference to the composition of the blood.

	Of the male.	Of the female.
Specific gravity of the blood	1060.2	1057.0
Water	780.0	791.0
Globules	140.0	127.0

The remaining constituents of the blood vary but little; the only difference being in the decimals.

ARTICLE III.

OF THE INFLUENCE OF AGE.

We possess but few documents respecting the influence of age upon the composition of the blood. The researches of MM. Denis and Lecanu require to be repeated, and upon a much larger scale than has hitherto been done.

It may be presumed that in infancy and childhood the blood contains a somewhat smaller proportion of albumen and globules; that its specific gravity is lower, and that it likewise contains a greater quantity of water. We are however entirely destitute of facts, respecting the composition of the blood in early life.

From the age of twenty to that of thirty, the mean proportions are about the same as those previously quoted. A similar analogy exists between the age of thirty and forty, with this exception, viz., that the cholesterine undergoes an increase; we have almost always found its proportion doubled after this period of life.

Between fifty and sixty-six (and we have never examined the blood of an individual who had passed that age), very little difference is to be found in the composition of this fluid. The fibrin, it is true, is somewhat diminished in quantity, its mean proportion being now represented by 2.0. The cholesterine, on the other hand, is found to have experienced a slight increase above the mean of middle age. The proportions of the remaining constituents remain within their natural limits.

In the human female, menstruation exerts an influence which acts as a species of substitute for that of age.

On this point, a minute analysis of facts has led us to the following conclusions. Before the appearance of the catamenia, the proportion of the globules is below the mean (127), and remains so until the discharge is fully established and free from all irregularity in point of time or quantity. When, however, this function has been fully established, the proportion of the globules increases and may oscillate between 127 and 137. When the critical period approaches and menstruation ceases, the proportion again falls. Thus, in one case, we found it at 121 and in another at 113.

ARTICLE IV.

OF THE INFLUENCE OF CONSTITUTION.

Science has acquired but few definite results, respecting this portion of our subject.

We have, however, framed two tables, the one comprising individuals endowed with healthy robust constitutions; the other, comprising those whose constitutions were somewhat below the average in this respect. These tables gave similar results; the numbers representing the mean proportion of the component parts of the blood, being almost the same in every instance. In spite of these data, the results which we have arrived at in disease, authorize the statement that, when the constitution is debilitated, the proportion of the albumen and globules undergoes a slight diminution, by no means equal, however, to that which occurs in disease. In a word, the blood contains less solid matters.

ARTICLE V.

OF THE INFLUENCE OF TEMPERAMENT.

Here again science possesses but few established facts. M. Lecanu has, however, stated that the globules were more abundant in persons endowed with a sanguineous temperament. We conceive that this distinguished observer has confounded plethora with the sanguineous temperament. M. Michel Levy asserts this temperament to be due to an excess of the blood globules, and the lymphatic temperament to a deficiency of the same. We cannot, however, accept these conclusions. The excess of globules exists concurrently with the state of plethora,—if, in truth, there be any excess. As for the sanguineous temperament, it is due to an increased development of the circulatory system, relative to the other organic apparatus of the body. As regards a decrease of the globules being considered characteristic of the lymphatic temperament, we can only say, that it appears equally improbable. A decrease of the globules constitutes anæmia: it may possibly occur with greater facility in persons of a lymphatic temperament than in others, but this is by no means constant. This temperament is, we conceive, due to a deficient amount of vitality in all the tissues of the body.

ARTICLE VI.

OF THE INFLUENCE OF ALIMENTATION.

The influence of alimentation, considered with respect to quality and quantity, plays an important part in the composition of the blood. It is this, in fact, which furnishes the elements destined to repair the incessant waste of the organism, and to supply the respiratory apparatus with the material necessary for combustion. The appreciation, however, of the influence in question, presents great difficulties. To accomplish this satisfactorily, it would be requisite to institute a comparative examination of the blood of persons presenting the same conditions of age, sex, and temperament, and subjected to different kinds of alimentation.

No such investigation has, as yet, been made; nor do we at present possess any analyses capable of solving the problem.

We can, however, by reference to certain pathological facts, and by the method of induction, establish a few general principles, which ulterior analyses may, perchance, eventually confirm.

1. Acute febrile diseases, in general, require a rigid restriction of diet: on the approach of convalescence, the condition of the blood demonstrates the effects of such restriction, provided always we bear in mind the changes which the disease itself may have produced.

2. Certain diseases of the stomach, especially cancer, frequently require low diet, the effects of which are manifested by special modifications of the blood.

3. Privation, misery, and the want of a sufficiently nourishing diet, likewise produce similar consequences.

In these cases, the result it is true is of a pathological nature; but this pathological condition is but the exaggeration of what may be produced by an analogous physiological condition. We recognize, therefore, the following results, as consequent upon a scanty innutritious diet, more especially if it be chiefly composed of vegetable matter.

1. *A decrease of the globules.*—This is, in fact, the most marked and characteristic modification. 125 in man, and 120 in woman, represent the lowest proportions consequent upon the above conditions, with respect to diet.

2. *Decrease of the albumen.*—This is, in general, but trifling, and cannot be estimated at more than $\frac{1}{4000}$ or $\frac{1}{5000}$—70 in 1000 is the lowest limit resulting from deficient nourishment.

3. *The fibrin* undergoes no particular change. It is probable, however, that a highly nitrogenized liberal diet may tend to its increase, and *vice versâ.*

4. *The chloride of sodium* is greatly diminished.

5. *The fatty matters* are somewhat increased. This singular phenomenon probably arises from absorption of the adipose tissue, under the influence of deficient alimentation.

To sum up, then, what we have stated respecting the physiological condition of the blood; we may admit such a condition to be compatible with various modifications of this fluid, when these are comprised within certain limits, which are as follows:

In 1000 *parts of blood.*

The water may vary . .	from	760	to	800
The specific gravity of the blood .	„	1055	to	1063
The globules	„	120	to	150
The fibrin	„	2	to	3.5
The solid matter of the serum . .				0.00
The cholesterine	„	0.075	to	0.150
The animal soap	„	1.00	to	2.00
The seroline	„	0.010	to	0.030
The chloride of sodium	„	2.00	to	5.00
The soluble salts	„	1.5	to	4.00
The phosphates	„	0.50	to	1.00

In 1000 *parts of serum.*

The sp. gr. of the serum may vary	from	1027	to	1032
The water of the serum . .	„	880	to	900
The albumen	„	70	to	90

SECTION VI.

MORBID IMMINENCE.

In common with other authorities, we apply this term to a general condition of the system which precedes disease, without actually being disease. It is that state, in which disease is on the point of being developed, and for the production of which, but a slight impulsion or trifling accidental cause is necessary. This morbid imminence occurs in relation to both acute and chronic diseases.

In the majority of cases, it is unaccompanied by any modification of the blood; in others, however, such modifications do occur, and are of two kinds—indeterminate and determinate.

This indeterminate modification of the blood is probably of frequent occurrence in many diseases; but no investigations have hitherto been made respecting it. The determinate modifications, however, may be referred to three groups, viz.—

1. Plethora;
2. Slight anæmia;
3. Pregnancy.

ARTICLE I.

PLETHORA.

What is plethora? The question is one upon which opinions are still much divided. Some, adopting the views of MM. Andral and Gavarret, regard it as due to an increased proportion of globules; others, following in the track of ancient authorities, consider it to depend upon an increase of the entire mass of the blood itself.

We are enabled, by means of analysis and induction, to offer a solution of the problem, which is not without importance, in reference to pathogenesis and therapeutics. The following propositions have been deduced from the results of our analyses.

1. In plethoric individuals, the composition of the blood remains entirely within the limits of health.

2. In many cases presenting an increased proportion of globules, exceeding, indeed, the physiological limits, no special symptoms are observed.

3. Symptoms of plethora may occur in connexion with every possible modification of the blood: they are always the same, and yield to the same therapeutic measures.

FIRST PROPOSITION.—*In plethoric individuals, the composition of the blood remains within the limits of health.*

In seven individuals affected with plethora (six males and one female), the following mean proportions were found to exist:

In 1000 *grammes of blood.*

Specific gravity	1059	
Water	780	
Globules	138	in the six males.
	131.5	in the female.
Fibrin	2.4	
Fatty matters	1.555	in the six males.
	2.150	in the female.

The proportions of seroline, cholesterine, and soap, were unchanged. That of the salts was so likewise:

Chloride of sodium	3.7
Soluble salts	2.9
Phosphates	0.341
Iron	0.547

An analysis of 1000 grammes of serum gave the following:

Specific gravity	1028
Pure albumen	80

SECOND PROPOSITION.—*In many cases, where a very large proportion of globules exists in the blood, no characteristic symptoms of plethora are observed.*

In the course of our experiments, we have frequently met with a very large proportion of the globules, especially under the following circumstances:

1. In certain cases of simple, uncomplicated jaundice;
2. In some cases of paraplegia, symptomatic of disease of the spinal cord;
3. In cholera;
4. In certain cases, the nature of which was not fully determined.

In all the above instances, the representative figure of the globules was found to oscillate between 150 and 180, and yet no symptom of plethora was present. Are we not, therefore, authorized to conclude, that an increased proportion of the globules may exist without plethora?

THIRD PROPOSITION.—*The symptoms of plethora may occur in connexion with every possible modification of the blood: they are always the same, and yield to the same therapeutic measures.*

These symptoms are: redness of the face; turgescence of all the tissues; sensation of fulness generally; cephalalgia; vertigo; ringing in the ears; large full pulse, not increased in frequency, and unaccompanied by heat of skin; tendency to active congestion and hæmorrhage.

As regards treatment, we may here state, that bloodletting alone, will relieve these symptoms, and even remove them entirely.

Returning to the subject of plethora, we shall endeavour to determine its nature, and at the same time to shew that, it may coexist with every conceivable modification of the blood.

If, as we have asserted, the composition of the blood in plethora undergoes no important change, to what are we to attribute that combination of symptoms which clearly has its point of origin in this fluid? Here we are carried back, as it were, by the process of exclusion, to the old idea, which attributed plethora to an increase in the mass of the blood itself. We consider, moreover, that such a condition may occur, whatever be the composition of this fluid, and that, as readily (although this is not so common) in cases where the globules are deficient, as in those where their proportion is natural.

powers; there is, however, no actual pain or suffering, no evident derangement of the functions, no bellows murmur in the vessels of the neck. This condition may be considered as a general anæmia, constituting a morbid imminence, or that stage of predisposition which precedes a certain number of acute and chronic diseases. This mild form of anæmia corresponds to a particular modification of the blood, which consists in a very slight decrease of the globules (from 110 to 120). The remaining constituents of the blood retain their normal proportions.

ARTICLE III.

OF THE ALTERATIONS OF THE BLOOD IN PREGNANCY.

The condition of pregnancy is one in which the blood undergoes the most remarkable changes; and these changes are such as generally to constitute a true morbid imminence. On examining separately the principal constituents of the blood, we arrive at the following conclusions:

1. *The globules.*—The proportion of the globules diminishes at a very early period of gestation, and this diminution, which varies with each individual, continues almost without interruption until the period of delivery, when the representative number of the globules is seldom higher than 100 for the mean.

2. *The albumen.*—The proportion of albumen is likewise sensibly diminished, but by no means so much so as that of the globules. This diminution is especially manifest, a short time prior to delivery.

3. *The fibrin* undergoes a marked increase, and the proportions 3.5 and 4.0 are met with pretty frequently.

4. As the results of the above alterations, we next notice a diminished density both of the blood and serum.

5. There exists a large proportion of fatty matter; as also of inorganic salts.

We append the following table, in proof of these statements:

Mean composition of the blood between the fifth and sixth months of pregnancy.

Analysis of 1000 *grammes of blood.*

Specific gravity of the blood	1051.5
Globules	111.8
Fibrin	3.5
Fatty matters	1.922
Salts	6.6

Analysis of 1000 *grammes of serum.*

Specific gravity of the serum	1025.5
Albumen	75.2

The blood may, however, undergo still greater changes. Thus, in some cases, the number which represents the globules falls below 100, and blowing murmurs become audible in the large vessels.

In other cases, the albumen falls as low as 65, and produces a general infiltration of the cellular tissue, very distinct from that œdema of the lower extremities which is the result of the mechanical pressure of the gravid uterus upon the vessels of the pelvis.

Lastly, there is another modification of the blood which frequently occurs during pregnancy, viz., an actual increase in quantity. A true plethoric condition is thus produced, affording an additional proof of the fact that, *plethora may exist whatever be the composition of the blood.*

A consideration of the changes which the blood undergoes in pregnancy, is not without importance. The decrease of the globules explains the debility which persists in many females for some time after delivery. The increase of the fibrin accounts for that predisposition to inflammation which exists during the puerperal state. Lastly, the decrease of the albumen, which is more considerable in some cases than in others, explains the tendency to puerperal fever; for we shall find one of the essential characteristics of this disease to be a great decrease of the albumen.

Practical Deductions.

The nature of the modifications to which the blood is liable, is of great importance in medical practice. In fact, we are sometimes placed in an embarrassing position with respect to these modifications. On the one hand, the plethora and tendency to congestion, which are so common in pregnancy, frequently necessitate the employment of bleeding; while, on the other hand, such a procedure cannot but still further diminish the proportion of both the globules and fibrin. It remains, therefore, for the practitioner to ascertain the degree of plethora which exists, together with the probable nature of the changes which the blood has undergone, in order to adopt a course which may prove beneficial to his patient.

SECTION VII.

OF THE ALTERATIONS OF THE BLOOD IN PARTICULAR DISEASES.

ARTICLE I.

OF THE PHLEGMASIÆ.

The modifications of the blood play an important part in the phlegmasiæ. They constitute the most distinct and decided characteristics of this class of diseases; they admit of less discussion than any others; and, lastly, they enable us to establish the phlegmasiæ as the most natural family in the nosological classification of disease.

These characteristics, foreseen by Ruysch and pointed out by Dehaen and other authors, were not, however, investigated in detail before the commencement of the present century. MM. Piorry, Bouillaud, etc., have studied them carefully, and we are indebted to these authors for having pointed out the buffy coat as one of the most characteristic and invariable marks of the phlegmasiæ. It is, however, to MM. Andral and Gavarret that we must attribute the most unexceptionable researches hitherto made, inasmuch as they are based upon accurate analyses.

Lastly, it is to these experimenters that we are indebted for having pointed out this signal fact: that *the proportion of fibrin is increased in all the phlegmasiæ.*

This is not, however, the only modification which takes place; and, after thoroughly investigating all the changes of the blood in the phlegmasiæ, we have been enabled to point out certain other alterations not less remarkable than the increase of the fibrin.

After a systematic exposition of these various modifications, we shall endeavour to propound a satisfactory theory of their production.

OF THE MODIFICATIONS OF THE BLOOD IN THE PHLEGMASIÆ.

(Analysis of 1000 grammes of blood.)

Specific gravity of the blood.—The specific gravity of the blood is always below the standard of health. This is owing to a simultaneous decrease of the albumen and globules.

The following table shews the specific gravity of the blood in some of the phlegmasiæ:

Mean specific gravity in the phlegmasiæ generally		1055.4
„ „ in acute bronchitis		1056.7
„ „ „ pleurisy		1055.0
„ „ „ pneumonia	1st bleedings	1052.6
	2nd „	1050.2
„ „ „ articular rheumatism		1055.5

From this we see that the specific gravity of the blood is lowest in pneumonia.

The globules.—The globules are likewise diminished in the phlegmasiæ. This is a fact of constant occurrence. Their mean decrease is about the same as in the case of disease in general; it presents nothing special, and may be attributed to the low diet to which individuals affected with inflammatory disease are necessarily subjected.

Weight of the globules in the phlegmasiæ generally		123.3
„ „ in acute bronchitis		122.5
„ „ „ pleurisy		120.4
„ „ „ pneumonia	1st bleedings	122.5
	2nd „	113.9
„ „ „ articular rheumatism		118.7

Of the fibrin.—The fibrin is invariably increased in quantity, and its quality is even said to be changed. This latter assertion, however, is far from being satisfactorily proved. We shall sum up our knowledge respecting the changes which the fibrin undergoes in inflammation, under the head of five distinct propositions:

1. The increase of the fibrin is, without exception, an invariable occurrence.

2. This increase of the fibrin commences with the invasion of the disease, and they both increase and decrease simultaneously.

3. The amount of increase on the part of the fibrin, is proportionate to the intensity and severity of the inflammation.

The following table is the result of our analyses:

Proportion of fibrin in the phlegmasiæ generally . . .	5.8
„ „ in acute bronchitis	4.8
„ „ „ pleurisy	6.1
„ „ „ pneumonia { 1st bleedings .	7.4
2nd „ . .	6.8
„ „ „ articular rheumatism . .	5.8

The maximum increase of the fibrin found by MM. Andral and Gavarret was 10. In general, the greatest increase has been found to occur in acute articular rheumatism, and in pneumonia.

4. This increase of the fibrin takes place equally in cases where the inflammation constitutes the sole disease, as in those where it occurs as a complication; such, for instance, as pneumonia arising during typhoid fever.

5. The influence of bloodletting upon the fibrin is very trifling. No real manifest decrease takes place until the subsidence of the inflammation itself.

Of the fatty matters.—We shall examine in succession—1. The cholesterine; 2. The animal soap (viz., the oleate, margarate, and stearate of soda).

1. *The cholesterine.*—The cholesterine is generally increased in the phlegmasiæ, as shewn by the following table:

Mean amount of cholesterine	in the phlegmasiæ generally			0.153
„ „	in acute bronchitis			0.166
„ „	„	pleurisy		0.182
„ „	„	pneumonia	1st bleedings	0.191
			2nd „	0.124
„ „	„	articular rheumatism		0.147

2. *The animal soap.*—(It was usually found in combination with a small quantity of cholesterine):

Mean amount	in the phlegmasiæ generally			1.563
„	in acute bronchitis			1.530
„	„	pleurisy		1.723
„	„	pneumonia	1st bleedings	1.566
			2nd „	1.464
„	„	articular rheumatism		1.479

It appears, then, from the above tables, that the fatty matters are increased in the phlegmasiæ.

We have nothing particular to notice respecting the *seroline.*

Of the salts.—*Chloride of sodium.*—Analysis shows a slight decrease of this salt in acute inflammations. Thus:

In the phlegmasiæ generally			3.1
In acute bronchitis			3.2
„	pleurisy		3.0
„	pneumonia	1st bleedings	3.1
		2nd „	2.8
„	articular rheumatism		3.5

Soluble alkaline salts.—These likewise experience a slight diminution, which is as follows:

In the phlegmasiæ generally			2.6
In acute bronchitis			2.8
„	pleurisy		2.0
„	pneumonia	1st bleedings	2.7
		2nd „	2.4
„	articular rheumatism		2.5

Phosphate of lime and insoluble phosphates:

In the phlegmasiæ generally			0.396
In acute bronchitis			0.327
„	pleurisy		0.478
„	pneumonia	1st bleedings	0.445
		2nd „	0.308
„	articular rheumatism		0.445

Analysis of 1000 *grammes of the serum of the blood.*

We shall here merely have to consider—1. The specific gravity of the serum; and 2. The quantity of albumen; that of the salts having been stated above.

1. *Of the specific gravity of the serum of the blood.*—A decrease in the specific gravity of the serum is a constant occurrence during acute inflammations. This assertion is borne out by the following table:

Mean specific gravity of the serum in the phlegmasiæ generally				1027.0
„	„	in acute bronchitis		1027.4
„	„	„ pleurisy		1026.0
„	„	„ pneumonia	1st bleedings	1025.0
			2nd „	1023.0
„	„	„ articular rheumatism		1025.0

2. *Of the amount of albumen.*—It is of the utmost importance to ascertain the amount of albumen contained in 1000 parts of serum; and with this view, we have carefully examined a very considerable number of cases, employing for the purpose the albuminimeter formerly alluded to.

By this means we have obtained the following results:

Sect. I.—Acute Bronchitis.

The composition of the serum was investigated in twenty-nine cases (twenty-three males and six females), with the following results:

Amount of albumen contained in 1000 *grammes of the serum of the blood.*

Mean	71.14
Maximum	76.52
Minimum	62.10

A marked diminution is here indicated. We must, however, remark, that in these cases the fever was moderate, and the disease free from danger.

Sect. II.—Pneumonia.

The albumen was made the subject of investigation in forty-four cases (thirty-one males and thirteen females) of pneumonia, for the aggregate of which, seventy-five bleedings were practised. Of these, forty-four were single bleedings; while, of the remainder, twenty-three were bled a second time, seven a third, and two a fourth time. Thus:

	Mean.	Maxima.	Minima.
1st Bleedings . . .	70.20	84.70	52.56
2nd „ . . .	65.43	85.14	52.92
3rd „ . . .	59.58	76.56	53.02
4th „ . . .	52.96	53.92	52.02

We have here, therefore, a considerable decrease of the albumen; and careful observation has proved to us that this decrease is in direct proportion to the intensity and extent of the inflammation. It is greater, moreover, according to the length of time that may have elapsed since the commencement of the disease, and to the frequent repetition of the bleedings.

The severity of the inflammation exercises a great influence over the decrease of the albumen. We have observed this in five very severe cases (four males and one female):

	1st Case.	2nd Case.	3rd Case.	4th Case.	5th Case.
1st Bleedings .	62.46	54.36	72.18	53.46	60.48
2nd „ .	61.92	42.52	59.94	52.92	57.60
3rd „ .	54.90	...	55.44	...	53.10
4th „ .	53.82	...	...	...	...

Whence the cause of this decrease? It must be attributed— 1. To the intensity of the inflammation; 2. To its extent; 3. To its duration; 4. To the influence of diet; 5. To previous venesection.

SECT. III.—Pleurisy.

The proportion of albumen was ascertained in seventeen cases of pleurisy (thirteen males and four females). Six of the number were bled twice:

	Mean.	Maxima.	Minima.
1st Bleedings . . .	75.50	90.00	60.48
2nd „ . . .	65.62	68.94	54.54

The decrease is, therefore, less than in pneumonia.

SECT. IV.—Erysipelas of the Face.

We have examined the albumen in twelve cases (six males and six females). Of these, three were bled twice:

	Mean.	Maxima.	Minima.
1st Bleedings	72.54	85.68	65.70
2nd „	65.42	62.48	62.82

We have here, likewise, a decrease of the albumen, about equal to that which occurs in pleurisy.

SECT. V.—Acute Articular Rheumatism.

The albumen of the serum was examined in twenty individuals (thirteen males and seven females) affected with acute articular rheumatism. Of these, ten were bled twice:

	Mean.	Maxima.	Minima.
1st Bleedings	76.68	87.48	62.46
2nd „	63.09	74.88	55.44

The decrease is here most marked after the second bleedings, being almost as great as in pneumonia. The somewhat high proportion found in the first blood drawn, is probably owing to the early stage of the disease, and to its occurrence in robust vigorous individuals, whose diet had not been restricted previous to their entrance into the hospital.

In conclusion, we append a table which shows the mean proportion of the albumen in the phlegmasiæ generally, and serves to prove, that in acute inflammations the decrease of the albumen of the serum is in direct ratio to the increase of the fibrin.

	Mean in general.	Bronchitis.	Pneumonia.	Pleurisy.	Erysipelas.	Acute Rheumatism.
Mean of 1st Bleedings	73.35	71.14	70.90	75.50	72.54	76.68
„ 2nd „	64.84	...	65.43	65.42	65.42	63.09

This decrease of the albumen, which is almost invariably recognized in the acute phlegmasiæ, may likewise occur in certain other diseases, hereafter to be considered.

The numerous details upon which we have thus dwelt, serve to establish the following facts relative to the alterations of the blood in the acute phlegmasiæ:

1. An increased proportion of fibrin;
2. A decrease of the globules;
3. A decrease of the albumen of the serum;
4. An increase of the fatty matters;
5. A decrease of the soda and soluble alkaline salts;

In addition, these different modifications are indicated by the formation of a whitish coat of varying thickness, upon the surface of the clot.

We shall now endeavour to explain these various phenomena.

1. *The increase of the fibrin and decrease of the globules.*

Two hypotheses, each based upon undeniable facts, may here be adduced.

The first is that which attributes the increase of the fibrin to the decrease of the globules, and which supposes the immediate principle of recent formation, constituting the fibrin, to be the result of a special transformation of the globules. This theory has been dwelt upon at length by Simon, in his treatise on animal chemistry.

His views may be summed up as follows.

The fibrin, in its normal physiological condition, is the result of the transformation of a certain amount of the globules. This transformation, which is of a vital nature, is due to the action of the oxygen of the atmosphere on the one hand, and on the other, to the numerous reactions which take place during the passage of the blood through the different tissues and organs of the body. The globules, before being assimilated to these tissues, and thus contributing to interstitial nutrition; pass through a transition state, which is the fibrin.

Now, in the phlegmasiæ, the circulation is more and more accelerated, in virtue of the reaction by which it endeavours to overcome the obstacle resulting from the inflamed part. The circulation, then, being quickened, the globules require more frequent contact with the oxygen of the air admitted into the lungs, and they pass oftener through the different tissues and organs. It follows, therefore, that more globules are converted into fibrin in the same space of time; hence an absolute increase of this element in the blood, and a decrease in the proportion of the globules, which are no longer renewed by the introduction of food and the process of assimilation.

But one objection can be made to this theory—viz., that these changes ought to take place whenever the circulation is accelerated, and, consequently, whenever fever exists. Why, then, should there not be, in this class of diseases, an increase of the fibrin, as in the phlegmasiæ?

2. *Increased proportion of the fibrin and decrease of the albumen.*—The second hypothesis supposes the increase of the fibrin to be due to the transformation of a certain amount of albumen into fibrin.

In the first place, the albumen is diminished; it must undergo, therefore, some change. Secondly, the quantity by which it is diminished is equivalent to the increase of the fibrin. Elementary analysis, moreover, shewed such an analogy between the atomic composition of the fibrin and that of the albumen, that their composition was long supposed to be identical, until it was at length admitted that the sole difference lay in the latter containing an atom more of sulphur.

We willingly, therefore, admit this transformation; albeit, open to certain objections. In the first place, how is it that it occurs simultaneously with the development of the inflammatory process? In answer to this question, the slight decrease of the alkaline salts has been brought forward, as perhaps favouring the transformation of a certain amount of albumen into fibrin; but this decrease is exceedingly small, and, moreover, we may ask, whence does it arise? If from restricted diet, why is not the fibrin increased whenever such diet is enforced?

In conclusion, we may admit that this increase of the fibrin is *probably* due to the transformation of a certain amount of albumen, occurring under the influence of the inflammatory process; but of which transformation we know neither the cause nor the mechanism.

3. *Decrease of the chloride of sodium.*—This decrease is

manifest. It results from restricted diet, and requires no further comment.

4. *Decrease of the alkaline salts.*—This decrease is very trifling, and, as before stated, we know nothing of its cause.

5. *Increase of the fatty matters.*—This increase is somewhat difficult to explain. We are, nevertheless, disposed to ask whether it may not be the result of low diet, and of the consequent absorption of the adipose tissues and their entrance into the blood.

ARTICLE II.

OF THE FORMATION OF THE BUFFY COAT.

An increase of the fibrin is almost always accompanied by the formation of what has been termed the buffy coat.

Whence the cause of this deposition of the fibrin, thus increased in quantity, upon the upper surface of the clot? What is its mechanism? Under what circumstances does it arise? To what modifications is it liable? These are problems, the solution of which is of great importance, inasmuch as chemistry can have but little scope in hospitals or in private practice, while the formation of the buffy coat is essential to the guidance of the practitioner, in the diagnosis and prognosis of disease.

The explanations which have been proposed, with a view of accounting for the formation of the buffy coat, are twofold.

In the first, the formation is explained by the increased proportion of the fibrin, whether absolute, or merely relatively so to the globules. It is alleged, moreover, that as the newly-created fibrin coagulates more slowly than that which originally existed, this latter, coagulating first, entangles all the globules in its meshes (thus constituting the red portion of the buffy coat), while the newly-formed fibrin is deposited somewhat later on its upper surface, constituting the white portion of the buffy coat.

The second hypothesis begins by admitting, that in the phlegmasiæ the globules sink below the surface of the serum more rapidly than in any other disease, or than in health. This being the case, it is possible to understand that they may carry down with them a portion of the coagulating fibrin, and thus form the red portion of the buffy coat, while the remainder of the fibrin, which still continues to coagulate, but more slowly, and without intermixture of the globules, all of these having been precipitated, presents a white or whitish yellow colour, and constitutes, by its progressive retraction, the buffy coat.

To either of the above theories, certain objections may be made. Thus, the partizans of the former may be asked, how it happens that, in the majority of chlorotic and anæmic cases, where there is no fibrin of recent formation, we yet find a buffy coat as thick, sometimes, as in the phlegmasiæ?

To those who advocate the latter hypothesis, we may say, If the globules sink more rapidly in the phlegmasiæ, it must be admitted that the same phenomenon takes place in chlorosis, and in other cases where the buffy coat is formed.

The analyses of which we have given a summary, as bearing upon the subject of the serum in its relation to the phlegmasiæ, may, perchance, permit us to contribute something to the study of the formation of the buffy coat.

Now in the first place, we have amply demonstrated the diminished density of the serum in the phlegmasiæ. The decrease of the globules (whether it be attributed to the disease or to low diet, matters little) is likewise a fact which cannot admit of doubt. Lastly, there is always, as we know, an increase of the fibrin.

These three facts being incontrovertible, may we not admit the following explanation, relative to the formation of the buffy coat?

In the phlegmasiæ, the subsidence of the globules below the surface of the serum takes place more rapidly, by reason of the modification which this fluid has undergone, and they carry with them a certain amount of fibrin, the subsidence of which is due to the same cause. The globules being, so to speak, saturated, experience all the phenomena of coagulation, in virtue of the progressive retraction of the fibrin with which they are intermingled, whilst that portion of the fibrin which does not subside along with the globules, is precipitated *per se*, and, coagulating, forms first a greenish, gelatiniform, quivering layer, which, after gradual condensation, becomes eventually the buffy coat, the thickness and density of which vary, in proportion to the amount and to the retractive power of the fibrin. Such an explanation as this appears to account, likewise, for the difficulty with which the buffy coat forms, when the blood, escaping *guttatim*, coagulates in a similar manner.

This, we repeat, is but an hypothesis; we may, however, here adduce a fact, which is the result of actual experiment.

In our analyses of the blood, this liquid was always received, and allowed to coagulate, in vessels whose height exceeded their breadth; and it not unfrequently happened, that the buffy coat did not form, in spite of the existence of a large amount of fibrin, a marked decrease in the specific gravity of the serum, and a proper flow of blood. We could nevertheless observe, that the upper stratum of the clot was more dense, and intersected by white streaks, indicating a larger proportion of fibrin in this, than in the lower part of the mass. This result may be explained by the form of the vessel: the globules, it is true, had subsided, but not with sufficient rapidity; when, therefore, the fibrin coagulated on the upper surface of the clot, it entangled within its meshes a certain proportion of the globules.

ARTICLE III.

PRACTICAL CONSEQUENCES TO BE DEDUCED FROM THE MODIFICATIONS OF THE BLOOD IN THE PHLEGMASIÆ.

If the treatment of a disease or class of diseases can be satisfactorily ascertained, by a previous acquaintance with the modifications of the blood, it is certainly that of the phlegmasiæ. Nor is this assertion difficult of proof.

In the phlegmasiæ, the chief therapeutic measures are threefold: 1. The antiphlogistic method properly so called; 2. The contro-stimulant method; 3. The expectant method. We shall merely consider the two first; but before doing so, we must remark that in the phlegmasiæ two points claim an equal share of attention: 1. The local element, viz., the inflammation of some organ or other; 2. The general condition, viz., an increase of the fibrin of the blood.

Sect. I.—Of the Antiphlogistic Method.

The antiphlogistic method of treatment, taken in its widest acceptation, consists in the withdrawal of a certain amount of blood from the system. It has been practised from remote antiquity, and was certainly not based upon a knowledge of the modifications of the blood, but rather upon empiricism.

This method, with all the improvements which the progress of medicine has contributed, is it, we would ask, satisfactorily explained by our knowledge of the alterations of the blood? To this question we do not hesitate to answer in the affirmative.

The study of the blood shews, in fact, that, under the influence of blood-letting, the proportion of fibrin diminishes; the vital fluid becomes, at the same time, less rich in albumen and globules, while its actual quantity is lessened. Under the influence of these changes and of restricted diet, the blood, in order to make up for the losses inflicted upon it by venesection, absorbs materials from every portion of the organism, and this process of absorption is exercised with the greatest activity upon the inflammatory lesion,—the foreign element, so to speak, which exists in the system. This process of reabsorption, which at length brings about the resolution of the phlegmasia, is satisfactorily explained by the more or less repeated employment of blood-letting.

This, however, holds good only with reference to moderate venesection, and a knowledge of the modifications of the blood teaches us not to carry this proceeding too far: for by so doing, we cause an undue decrease of the albumen and globules, and leave the patient in that anæmic condition which impedes convalescence, or at least renders it exceedingly protracted.

SECT. II.—Of the Contro-Stimulant Method.

The beneficial results derived from the administration of large doses of tartar emetic in some of the phlegmasiæ, especially in acute articular rheumatism and pneumonia, cannot be denied. But does our knowledge of the blood and its modifications explain these results? On this subject we can but suggest what is, after all, hypothetical. We know that fibrin is readily soluble in a solution of certain alkaline salts, and that these solutions may even be very diluted, inasmuch as one part in a thousand of such a salt, the nitrate of potash for example, is sufficient to act as a solvent upon the fibrin. May not the introduction of tartar emetic into the blood be capable of exercising an influence similar to that which nitrate of potash exerts upon the fibrin when removed from the body? If this solvent power really exist, we may conceive it to act not merely upon the newly formed fibrin, an excess of which exists in the blood, but likewise upon the plastic deposits formed by the fibrin, which, infiltrating the inflamed tissues, constitute the anatomical characteristic of the phlegmasia.

If what we have now advanced, simply as an hypothesis, were strictly true, the beneficial influence of tartar emetic in certain inflammations, and more particularly in pneumonia, would be tolerably well explained. Its action would therefore be very different from that of blood-letting. This latter, in fact, promotes a reabsorption of the product which constitutes the inflammation itself, and causes a diminution of the fibrin; whilst the former exercises a solvent action, not merely upon the excess of fibrin in the blood, but upon the plastic products which infiltrate the diseased organ and maintain its inflammatory condition.

ARTICLE IV.

OF THE ALTERATIONS OF THE BLOOD IN CERTAIN PHLEGMASIÆ IN PARTICULAR.

Hitherto we have considered the phlegmasiæ in a general point of view, and the details upon which we have dwelt are nearly applicable to all. We need not therefore revert to them. In acute tonsillitis, bronchitis, pneumonia, pleurisy, erysipelas of the face, and acute rheumatism, the changes in the blood, of which we have just spoken, occur without exception, and require no further comment.

There are, however, two morbid conditions, not always classed with the phlegmasiæ, but of which we would wish here to speak. The first is acute endocarditis. The second comprises the majority of the puerperal phlegmasiæ, together with that peculiar morbid condition which many practitioners hesitate to consider either as a phlegmasia or as a fever. It is this combination which constitutes the disease, frequently termed by some, puerperal fever, and by others, puerperal metro-peritonitis, uterine phlebitis, etc.

Sect. I.—Acute Endocarditis.

When acute endocarditis occurs as a complication during an attack of acute rheumatism, it is merely regarded as a more or less important accessory to the original disease, and the modifications of the blood to which it may give rise, are confounded with those which we have seen to take place in acute articular rheumatism. It is, therefore, with idiopathic endocarditis alone that we have to do. Few details respecting it are to be found in the archives of science, and we can only offer those which we have ourselves ascertained. Having met with ten cases of acute idiopathic endocarditis, we were anxious to discover whether the blood, in this disease, underwent those modifications which have been found to occur in the phlegmasiæ generally. We shall now give the result of our observations, together with the analyses of the blood in the above cases.

Of these ten cases, seven occurred in males and three in females. Of the former, one was fifteen years of age, two were twenty-seven, one forty, two forty-one, and one sixty-five years of age. The three females had respectively attained the ages of twenty-one, thirty-four, and thirty-six.

The symptoms of acute endocarditis were very characteristic. The force and extent of the heart's impulse were much increased, and this latter was often extremely irregular. A bellows murmur with the first sound was present in every case, whether the action of the heart were regular or irregular. In all there was high fever, with great heat of skin. In three of the cases we noticed a greater or less degree of infiltration in the lower extremities.

The following is the result of the analysis of these ten cases:

Analysis of 1000 *grammes of blood.*

	Mean.	Maxima.	Minima.
Specific gravity of the blood	1053.81	1060.79	1048.24
Water	789.80	...	...
Globules	122.56	146.45	92.23
Solid matters of the serum .	83.06	104.60	67.16
Fibrin	4.58	7.51	3.09

Analysis of 1000 *grammes of serum.*

	Mean.	Maxima.	Minima.
Specific gravity of the serum	1028.26	1038.80	1021.05
Water	906.10	...	...
Albumen	74.46	94.16	55.48
Extractive matter and salts .	19.44	28.70	11.34

The Globules.—In four cases the representative figure of the globules rose somewhat above 130. In two others it ranged between 120 and 130. Lastly, in four others it fell below 120, and once indeed to 92.

The Fibrin.—Its proportion was always greater than in health: it rarely, however, rose as high as in pneumonia or in acute articular rheumatism; thus,—

In one case it rose to	7.51
In four cases „	between 4 and 5
In one case „	5.75
In four cases „	between 3 and 4

These proportions are constantly met with in the ordinary phlegmasiæ.

Of the albumen contained in 1000 *grammes of serum.*

Its mean proportion differed little from that of health, but its extremes of variation were somewhat considerable, viz., 94.16, and 55.48. In four cases it rose above 80; in three it ranged between 70 and 80; in two between 60 and 70; and in one case it fell below 60.

The extractive matters, fatty matters, and free salts contained in the above quantity of serum, are represented by much higher numbers than in health (19.44, instead of from 10 to 12).

These analyses prove the necessity of moderate blood-letting in the treatment of idiopathic endocarditis. The trifling increase of the fibrin, however, in this disease, indicates the propriety of caution in the use of such a measure.

Sect. II.—Puerperal Fever.

The alterations of the blood in puerperal fever are of considerable interest. It is the disease in which, perhaps, of all others, it undergoes the greatest changes. In our previously published researches, we had pointed out the invariable increase of the fibrin, together with the marked decrease of the albumen in this affection. Since then, M. Hersent, in a long and interesting communication, has confirmed these facts. The following are some of the conclusions at which he has arrived:

"1. The modifications of the blood in severe puerperal fever "consist—1. In a great increase of the watery element; 2. "In a very considerable decrease of the globules; and 3. In an "equally marked decrease of the albumen.

"2. The severity of the disease is in proportion to the "extent of these changes."

Passing over the third and fourth propositions, which are foreign to our subject, we find that M. Hersent considers:

"5. That, in all probability, these changes in the blood pre-

"cede the development of the disease, of which, however, they "cannot be regarded as the cause: their existence, nevertheless, greatly aggravates the severity of the attack."

With a view of throwing some light upon this subject, we have recently analysed the blood of four females suffering from severe puerperal fever.

Their respective ages were eighteen, twenty, twenty-six, and thirty-two years.

One had arrived at the third day of the disease, another at the fourth, another at the sixth, and another at the seventh.

In each of these cases, the heat of skin was very great, the pulse frequent, the fever high, while certain characteristic abdominal symptoms (tympanitis, tenderness on pressure, etc.) indicated at least the existence of peritonitis.

These four individuals, each of whom was bled on the day after admission into hospital, afforded specimens of blood so similar in point of composition, that we shall merely give the mean results as deduced from analysis.

Analysis of 1000 *grammes of blood.*

Specific gravity of the blood	1050.21
Water	791.03
Globules	140.96
Solid matters of the serum	61.25
Fibrin	6.76

Analysis of 1000 *grammes of serum.*

Specific gravity of the serum	1023.16
Water	929.25
Albumen	58.26
Extractive matters and salts	12.49

Several conclusions may be drawn from the above tables. Thus, in the analyses of these four cases, the *density* of the blood and of the serum is notably diminished.

The proportion of *globules* is generally very considerable, being far greater than the mean of health in the female.

The *solid matters* of the serum are much diminished in quantity.

The *fibrin*, on the other hand, is greatly increased.

The *albumen* of the serum undergoes a marked decrease, to which must be attributed the low specific gravity of the serum.

Practical Consequences to be drawn from the Modifications of the Blood in Puerperal Fever.

The increased proportion of fibrin would appear to indicate the necessity for bleeding; we know, however, that blood-letting is far from being the most satisfactory therapeutic agent in this disease. The analysis of the blood serves to explain this, as it evidently results from the great decrease of the albumen of the serum; and in the numerous analyses which we have made of this liquid, we have constantly remarked, that those individuals whose serum was of low specific gravity, by reason of its small proportion of albumen, bore blood-letting with difficulty.

ARTICLE V.

OF THE MODIFICATIONS OF THE BLOOD IN THE PYREXIÆ.

The composition of the blood has been as fully investigated in the pyrexiæ as in the phlegmasiæ. Long previous to the possibility of carrying out this inquiry in a satisfactory manner, upon positive chemical and physical data, attempts were made to ascertain the qualities of the blood in this interesting class of diseases. We have endeavoured to show, in the historical sketch at the commencement of this volume, that the existence of a particular state of the blood in severe fevers, had been admitted, from the earliest periods up to the present time; this state consisting of a real fluidity, and even of a complete liquefaction of the blood. The fact, however true, holds good in only a certain number of cases; and the earlier writers were in error, when they attempted to generalize upon a special condition, and to apply the same to all severe fevers. It is to MM. Andral and Gavarret, again, that we are indebted for having definitely ascertained the chief characteristics of the blood in the pyrexiæ. These are as follows.

In the pyrexiæ—and under this title we comprehend typhoid fever, measles, scarlet fever, small-pox, leaving intermittent fevers aside for the present—the fibrin is never increased in quantity, unless these affections be complicated with one or other of the phlegmasiæ, of a certain extent and severity.

This, it is true, can but be regarded as a negative characteristic; as such, however, it is of no little importance, more especially if placed in juxtaposition with the increased proportion of the fibrin in the phlegmasiæ.

But the fibrin does not merely remain within the limits of health; it sometimes undergoes a considerable decrease, and hence have been explained the fluidity and liquefaction of the blood, occasionally observed in certain of these cases. It is, moreover, to the decrease of the fibrin, that have been attributed the hæmorrhages which often usher in typhoid fevers, and which not unfrequently complicate the severer forms of the eruptive fevers.

In their first work, MM. Andral and Gavarret stated that the blood, at the commencement of the eruptive fevers, contained a larger proportion of globules than in health. They have now, however, renounced this opinion, upon which we need not therefore insist.

The modifications of the blood in the pyrexiæ may, we conceive, be summed up in the following propositions.

1. In many of the pyrexiæ, the composition of the blood differs but little from that of health; when the disease, however, is somewhat prolonged, the globules and albumen undergo a slight decrease.

2. In a certain number of the pyrexiæ, and especially in typhoid fever, when prolonged, and of adynamic type, the fibrin is found to be considerably diminished in quantity, and, as a consequence, the blood becomes more fluid and less coagulable. 0.9 represents the smallest proportion of fibrin that we have yet met with under these circumstances.

3. In a certain number of fevers—occasionally in the typhoid,

but more generally in the eruptive fevers—the disease presents an hæmorrhagic character from its very commencement. This is due to the decrease of the fibrin. In such cases, the fluidity and diminished coagulability of the blood are, likewise, marked characteristics.

Sect. I.—Typhoid Fever.

Is it true, that in the majority of typhoid fevers the blood is so changed as to be semi-fluid and partially uncoagulable? Such is the problem which we propose now to elucidate.

MM. Andral and Gavarret have published several analyses of the blood in typhoid fever, and they have obtained the following results as regards the globules and fibrin. We here quote the mean proportions only.

Globules.

	Mean.	Maxima.	Minima.
1st Bleedings	125.1	146.7	77.4
2nd "	121.5	136.7	92.6
3rd "	100.7	...	...
4th "	96.9	...	...
5th "	80.4	...	...

Fibrin.

1st Bleedings	2.7	...	...
2nd "	2.7	...	...
3rd "	2.4	...	...
4th "	1.5	...	...

In two cases, where venesection had been practised for the fifth time, the proportion of fibrin was found to be 2.1 and 1.0.

Our own analyses have led to very similar results.

Analyses of 1000 *grammes of blood.*

	1st Bleedings.	2nd Bleedings.
Specific gravity of the blood	1054.1	1051.4
Globules	124.5	113.5
Fibrin	2.3	2.1
Cholesterine	0.055	0.156
Animal soap	1.428	1.232
Chloride of sodium	3.6	3.5
Soluble salts of soda	2.6	2.7
Phosphates	0.544	0.355

In three severe cases of the adynamic type, the following proportions of fibrin were found in the blood.

	1st Case.	2nd Case.	3rd Case.
1st Bleedings	2.0	3.5	2.7
2nd „	1.4	2.8	1.3

Analyses of 1000 *grammes of serum.*

	1st Bleedings.	2nd Bleedings.
Specific gravity of the serum . .	1026	1023

Albumen.—We have endeavoured to ascertain the exact proportion of albumen in three series of cases. In the first series, comprising nine cases, in each of which venesection had been practised once, the mean amount of albumen was 68.04; the maximum, 74.34; the minimum, 62.64. In the second series, comprising twenty-five cases, seventeen were bled once, six were bled a second, and three a third time.

Of the seventeen first bleedings, the mean density was found to be 1026.

The proportion of albumen was 70.01.

The quantity of serum was somewhat variable. In sixteen cases that were carefully examined, it was found, in seven, to be tolerably abundant in proportion to the volume of the clot. In four of these seven cases it was limpid and transparent; in two it was somewhat turbid; in one it was decidedly turbid, and contained a few globules. In the nine remaining cases, the serum was twice found to present no abnormal characteristic; in three it was limpid, transparent, and scanty; in four it was scanty and turbid.

Its colour was generally rather deep, and on several occasions it was found to be very thick and viscid.

The statement, therefore, that in all cases of typhoid fever the serum is scanty, turbid, and mixed with globules, is evidently erroneous.

In the second bleedings, the average density of the serum was 1024.8.

The proportion of albumen, 64.5.

The amount of serum was very variable.

In a third series of cases, wherein we analyzed, on ten occasions, the serum afforded by first and second bleedings, the following results were obtained:

	1st Bleedings.	2nd Bleedings.
Specific gravity of the serum .	1025.	1024.5
Amount of albumen	69.45	66.931

From the foregoing analyses, we learn how unfounded was the ancient idea relative to the existence of a black, fluid, uncoagulable condition of the blood, in all typhoid fevers. Doubtless, this may sometimes be the case; but it is certainly very rare. Whatever information science possesses on this head, may therefore be summed up in the two following propositions.

First proposition.—At the onset of typhoid fever, there is rarely observed any modification of the blood. Sometimes, however, in very severe cases, accompanied by hæmorrhage and great prostration, there is a simultaneous decrease of the three principal elements of the blood, and more especially of the fibrin.

Second proposition.—When the disease is fully formed, the globules and albumen diminish under the influence of low diet, and of the evacuations (diarrhœa, epistaxis, etc.) which the patient usually experiences; the fibrin remains unchanged, or tends to diminish, in proportion to the advance or aggravation of the disease. It is more especially in the very severe adynamic form of typhoid fever that the fibrin undergoes the greatest diminution.

Practical Consequences to be drawn from the Modifications of the Blood in Typhoid Fever.

Do the results of an analytical examination of the blood in typhoid fever admit of any therapeutic deductions? To this question we think it possible to reply in a measure.

In the first place, then, our knowledge of the composition of the blood in this disease must tend to exclude the employment of bloodletting in the majority of cases, unless complicated with one or other of the phlegmasiæ. How, indeed, can it be otherwise? We have previously shewn that venesection impoverishes the blood in proportion to its repetition; while, in typhoid fever, this fluid has of itself a similar tendency, which is but too well marked.

It should, moreover, be remembered, that typhoid fever is a long and severe malady, for which it is necessary to preserve the patient's strength as much as possible, in order to enable him not merely to struggle through the disease, with its category of chances, but likewise to sustain the protracted convalescence which usually occurs in these cases. Profuse bloodletting cannot but be injurious under such circumstances.

Lastly, in ordinary convalescence from typhoid fever of moderate severity, the blood is much impoverished, and the patient not unfrequently presents a marked anæmic condition, which lasts for a considerable time, and is often somewhat difficult to remove. Bloodletting, therefore, practised during the disease, does but tend to increase that which is of itself produced during convalescence,—viz., anæmia.

This impoverishment of the blood, occurring during the progress of convalescence, indicates the necessity for tonic remedies.

SECT. II.—Typhus Fever.

In 1847, M. H. Guenaud de Mussy and M. Rodier were sent by the French Government to Ireland, with a view of investigating the nature of the fever (typhus) which, at that time, prevailed there to a great extent. The former undertook the pathological portion of the investigation, while the latter confined himself to the analysis of the blood, and such was the kindness of the Irish physicians on this occasion, that he found free access to all the hospitals, and was enabled to carry out, within their precincts, all the necessary chemical manipulations. It was intended to have published a complete treatise on this disease; events, however, decided otherwise; and it is probable that this work may never see the light. We possess, however, the analysis of the blood in six cases of typhus fever, which we give below, as contributing in some degree to the history of the disease in question.

Table shewing the analysis of the blood in six cases of typhus.

Analysis of 1000 *grammes of blood.*

	1st Case. Male.	2nd Case. Male.	3rd Case. Male.	4th Case. Male.	5th Case. Female.	6th Case. Female.
Specific gravity of the blood . .	1055.5	1047.0	1050.9	1042.1	1051.2	1041.2
Globules . .	146.5	113.5	138.1	97.	126.8	95.6
Solid matters of the serum . .	75.4	71.1	60.1	72.0	70.0	71.7
Fibrin . . .	2.3	1.2	2.8	3.9	2.5	2.1
Water . . .	755.8	814.2	799.0	826.9	800.7	830.6

Analysis of 1000 *grammes of serum.*

Sp. gr. of the serum	1022.1	1021.4	1017.5	1020.0	1024.1	1020.0
Solid matters .	91.8	80.8	69.8	80.0	82.6	79.2
Water . . .	908.2	919.2	930.2	920.0	917.4	920.8

We must here observe, that these analyses were made before the application of the *polarimeter* to the investigation of the albumen, had permitted an accurate study of this latter constituent of the blood.

The following conclusions may be drawn from the above severe cases of typhus fever:

1. The *specific gravity of the blood* is generally much diminished.

2. The *globules*, which in two cases (males) remained unchanged, were greatly diminished in two others; the same thing occurred in a female (case sixth).

These differences must be sought for in the previous condition of the patient, in the nature of his diet and regimen, and especially in the anæmic state which was present; as this modification on the part of the globules is not due to the disease itself.

The *fibrin* either remained unchanged, or fell below the limits of health; this tendency to decrease is therefore a fact worthy of notice.

The *specific gravity* of the serum was, in general, much diminished. This diminution being, in all probability, produced both by the disease and its dietetic treatment: it was, however, much more marked in one case than in the others.

SECT. III.—Small Pox.

We possess but few analyses of the blood in this disease, MM. Andral and Gavarret alone having investigated the subject. They analyzed this fluid in seven cases, in which venesection had been practised fourteen times, and obtained the following results.

In five cases of confluent small pox, the globules, in general, suffered no diminution, except in one case. The fibrin at the first bleeding was somewhat increased in quantity; it invariably, however, underwent a subsequent decrease. To explain the increase alluded to, MM. Andral and Gavarret ask whether this modification of the blood, although slight, may not reflect in a measure the inflammatory action of which the skin is the seat.

The following table shews the results obtained by these authorities:

First bleedings in five cases of severe small pox.

						Mean.
Globules .	120.6	114.3	127.9	126.5	98.8	117.5
Fibrin .	4.4	3.0	2.6	1.1	2.9	2.4
			Second bleedings in ditto.			
Globules .	110.2	92.6	124.4	124.9	...	113.0
Fibrin .	2.9	3.2	3.5	2.0	...	2.9
			Third bleedings in ditto.			
Globules .	94.6	88.4	...	...	...	...
Fibrin .	3.2	3.0	...	...	...	...
			Fourth bleedings in ditto.			
Globules .	87.0	...	...	...	...	...
Fibrin .	3.3	...	...	...	...	...

In two cases of varioloid disease, no modification of the blood was discovered.

SECT. IV.—Measles.

MM. Andral and Gavarret having analyzed the blood in seven cases of measles, obtained the following results.

The fibrin in each case remained within its normal limits, 3.6 to 2.6.

The globules were increased in four cases: 146.9; 140.6; 137.0; 137.1; and in another, 123.9. In two cases they were diminished: 118.6 and 116.1. The lowest proportions were found in those instances where the bleeding had been practised at a somewhat remoter period from the commencement of the disease.

We have ourselves analyzed the blood in three cases of measles, with the following results.

A man, aged twenty, was bled twice.

The analysis of 1000 grammes of blood gave the following proportions: globules, 146.1; fibrin, 2.8; and in a second bleeding—globules, 126.6; fibrin, 3.8.

The analysis of 1000 grammes of serum gave the following:

	1st Bleeding.	2nd Bleeding.
Density	1026.3	1026.7
Pure albumen	70.8	73.4
Fatty matters	1.13	1.22

In a second case, the results obtained were as follows:

In 1000 grammes of blood	Globules	115	Fibrin	2.2
In 1000 grammes of serum	Pure albumen	73.1		

These proportions, as may be seen, differ but little from those of health. It would probably, however, be otherwise, had we to deal with cases presenting an inflammatory or hæmorrhagic complication.

SECT. V.—Scarlatina.

MM. Andral and Gavarret have only examined the blood in two cases of scarlet fever. They found the proportion of fibrin to be perfectly normal, while that of the globules was greater than in health. Thus:

	1st Case.	2nd Case.	1st Case, bled during convalescence.
Fibrin	3.1	3.5	4.0
Globules . . .	146.6	136.1	124.3
Solid matters of the serum	89.4	84.1	89.1
Water	761.5	776.3	782.6

SECT. VI.—Intermittent Fever.

MM. Andral and Gavarret have analyzed the blood of six individuals labouring under intermittent fever, with the following results.

The fibrin either remained within the limits of health, or was very slightly increased: 3.7; 3.5; 3.5; 3.4; 3.3; and 3.0. The globules: 127.9; 110.4; 109.5; 105.8; 105.0; 68.8. In this last case, the patient was chlorotic.

It is evident from this, that the composition of the blood in intermittent fever, differs but little from that of health. It must, however, be understood, that we do not here speak of that condition to which the term *marsh cachexy* has been applied, and of which we shall treat at length in another part of the work.

MM. Léonard and Foley, of Algiers, have examined the composition of the blood in intermittent fever. The following are the conclusions at which they have arrived:

" 1. At the commencement of the disease, whatever its type, " the proportion of fibrin oscillates between the *maxima* and " *minima* of health.

" 2. It decreases under the influence of a relapse, without, " however, falling below the minimum of health.

" 3. The transition from the intermittent to the remittent, " and from thence to the continued form of the disease, pro- " duces no variation in the proportions of this constituent of " the blood.

" 4. Of the complications likely to arise during intermittent "fever, those only which are purely inflammatory, increase the "amount of fibrin.

"5. The congestion of internal organs, common to all forms "of intermittent fever, occasionally runs into actual inflamma-"tion, and may in this manner increase the proportion of "fibrin.

"6 and 7. The cause which determines the engorgement of "the spleen is not due to the decrease of the fibrin, which "varies in different cases.

"8. The proportion of globules is rarely increased; it tends "either to remain stationary or to diminish.

"9. The organic and inorganic matters of the serum have a "tendency to diminish; the same may also be said of the "albumen.

"10. The water is generally increased in quantity."

SECT. VII.—Ephemeral Fever.

Simple continued fever,—the *prolonged ephemeral fever* of many authors,—consisting of a more or less marked febrile state, with headache, etc., etc., but without any local determination, is one of those diseases upon the nature of which, authorities are not, as yet, perfectly agreed. It is important, therefore, to ascertain the composition of the blood in this affection.

As the result of our own analyses, we may state: 1. That the density of the blood is the same as in health, and that the proportion of water is so likewise; 2. That the globules attain their utmost physiological limits; 3. That the fibrin remains the same as in health; 4. That the albumen and salts alone undergo a trifling decrease, which is, however, rather the result of low diet than of the disease itself.

We here subjoin the mean proportions afforded by the analysis of the blood in eight cases of the disease in question. They serve to demonstrate the truth of the above propositions.

Analysis of 1000 *grammes of blood.*

Specific gravity	1056.8
Globules	142.4
Fibrin	2.8
Cholesterine	0.112
Animal soap	1.568
Soluble salts	2.7
Chloride of sodium	2.8
Phosphate of lime	0.321

Analysis of 1000 *grammes of serum in* 21 *cases.*

Specific gravity of the serum	1025.5
Pure albumen	76.61

The practical consequence deducible from the above analyses is simply this: that the composition of the blood being identical with that of health, or nearly so, there can be no necessity for blood-letting. Those who would employ it under such circumstances, must base their practice upon a totally different mode of reasoning.

SECT. VIII.—Cholera.

Simon was among the first to examine the blood in cholera. He asserts that in this disease the proportion of water diminishes, while the solid matters undergo a remarkable increase; at the same time, there occurs a concentration of urea in the blood, and an augmentation in the proportion of fibrin. The former of these two phenomena does not appear, however, to have been proved by subsequent analyses.

It would seem from an analysis of Wittstock's, that the physical characteristics of the blood in cholera, are identical with those of health. Its density being 1038.5, and the proportion of solid matters 137.5 in 1000.

An analysis of Simon's gave the following results:

Water	740.0
Fibrin	11.0
Albumen	110.42
Globules	124.46
Extractive matters and salts	14.10

O'Shaughnessy has given the following analysis:

Water	834.0
Albuminous matters	133.0
Urea	1.4
Fatty matters	1.4
Alkaline chlorides	4.0
Sulphates	1.6
Extractive matters and albuminate of soda	4.8

Lastly, another analysis by Simon gave:

Water	750.530
Fibrin	2.47
Fatty matters	5.434
Albumen	114.114
Globules	108.529
Extractive matters and salts	10.631 among
which were found, ammoniacal salts	5.41

According to Heller, the blood when examined after death was found to be rich in albumen, fatty matters, and urea. It contained a large proportion of chlorides, and the fibrin remained unchanged as regards quantity.

In presence of such discrepant results, it became a matter of interest to ascertain the actual composition of the blood by the employment of the same methods of analysis which we had hitherto made use of. This was accordingly done, and the following are the results of a complete analysis of the blood made in two very severe cases of cholera, and of four analyses of the serum made under similar circumstances.

Analysis of 1000 *grammes of blood,*

In a man thirty years of age, bled on the morning of his decease.

Specific gravity	1074.10
Water	722.52
Solid matters	277.48
Globules	189.60
Fibrin	1.88
Albumen	51.80
Chloride of sodium	6.61
Fatty matters, salts, and extractive matters	27.59

In a man thirty-five years of age, bled on the morning of his decease.

Specific gravity	1075.0
Water	753.95
Solid matters	245.05
Globules	160.20
Fibrin	6.50
Albumen	69.35
Extractive matters, fatty matters, and salts	20.0

Analysis of 1000 *grammes of serum.*

In a man twenty-nine years of age, bled at the commencement of the typhoid stage.

Specific gravity	1041.50
Water	888.30
Solid matters	111.70
Albumen	63.10
Chloride of sodium	12.26
Fatty matters	4.70
Extractive matters and salts	31.70

In a man twenty-six years of age, bled during the stage of reaction.

Specific gravity	1035.10
Water	901.79
Solid matters	98.21
Albumen	48.21
Chloride of sodium	7.38
Fatty matters	4.23
Extractive matters and salts	38.48

In a man thirty years of age, bled on the morning of his death for cerebral congestion.

Specific gravity	1042.20
Water	893.70
Solid matters	106.30
Albumen	64.20
Chloride of sodium	8.82
Fatty matters	not separated
Extractive matters and salts	36.68

In a man thirty-five years of age, bled seven hours before death for cerebral congestion.

Specific gravity	1035.10
Water	886.60
Solid matters	113.40
Albumen	84.66
Chloride of sodium	not separated
Fatty matters	not separated
Extractive matters and salts	28.74

From these tables we may draw the following conclusions :

The density of the serum is much greater than in health ; the proportion of water is diminished ; that of the solid matters, generally, much increased. The albumen varies but little, if anything it has rather a tendency to diminish. The chloride of sodium undergoes a considerable increase, inasmuch as its proportion is nearly one-third more than usual: it must, therefore, have become concentrated in the blood. The fatty matters are nearly doubled in quantity, and the extractive matters are likewise very abundant.

In our analysis of the blood itself, similar results were obtained, together with a high specific gravity, and a very large proportion of globules. The blood coagulated with extreme difficulty, and it was only after much trouble, that even a small quantity of serum could be obtained.

In presence of such results, and more especially when placed in juxta-position with the analysis of the stools and vomited matter of cholera, of which we shall speak hereafter, it is possible, in a certain degree, to explain the phenomena of this disease. In fact, a portion of the solid matters of the serum, more especially the albumen, is exhaled by the mucous membranes. The blood becomes less fluid, and the stools more watery. The consequence of this escape of water is a concentration of the globules, extractive matters, chloride of sodium, etc. The decrease of the albumen of the serum being explained by its presence in the intestinal secretions. As for the increased proportion of fatty matters, may it not be attributed to the extremely rapid absorption of adipose matter which takes place in cholera.

ARTICLE VI.

OF THE BLOOD IN THE HÆMORRHAGES.

This class of diseases is one of those upon which the greatest amount of light has been thrown by a study of the modifications of the blood. It is necessary, therefore, to examine the subject in detail.

In the present state of knowledge, the hæmorrhages may be divided into three principal groups.

1. Hæmorrhages due to an alteration of the solids;
2. Hæmorrhages due to some well-known modification of the blood.
3. Hæmorrhages due, in all probability, to some modification of the blood not yet determined.

SECT. I.—Hæmorrhage by alteration of the Solids.

It belongs not to our subject, here to treat of hæmorrhages in an historical point of view. We may, however, rapidly enumerate them.

Hæmorrhages due to an alteration of the solids, comprise those which are caused by the lesion of an artery or vein. Such, for instance, as wounds or ulcerations, involving vessels of large calibre, viz., simple ulceration, varicose, gangrenous, cancerous, and tubercular ulceration. The softening of tissues, by diminishing the resistance of the vascular walls and the support afforded them by the tissue with which they are in contact, is a frequent cause of hæmorrhage. Such is not unfrequently the origin of cerebral hæmorrhages.

Those hæmorrhages termed *mechanical*, are likewise due to an alteration of the solids; they are the result of mechanical sanguineous congestion carried to its utmost limits. Such are the hæmorrhages which occur during the progress of certain diseases of the heart and of cirrhosis of the liver.

There are certain forms of hæmorrhages due to a *specific local cause*, which may be termed irritation; such are the hæmorrhages so frequently observed in the early stages of cancerous and tubercular disease. In these cases we may often meet with hæmorrhage from the mucous membrane of the bronchi and stomach, long prior to the occurrence of ulceration.

Lastly, there are certain hæmorrhages the cause of which is unknown; they are not attended by any general modification of the organism, but are usually classed with hæmorrhages due to an alteration of the solids.

SECT. II.—Of Hæmorrhages due to certain well-known definite Modifications of the Blood.

This modification on the part of the blood is one of quantity and quality. In a work published by us some time since, we included these hæmorrhages under one head, which we termed "*the scorbutic state*". Not perceiving sufficient reason for changing the name, we shall retain it.

In health, the proportion of fibrin is 2.5 in 1000 parts of blood. As its physiological limits may be represented by the numbers 2 and 3, it follows that the fibrin must fall below 2 before we can consider it as having undergone any decrease.

This decrease may be but a symptomatic condition, common to a certain number of acute and chronic diseases. It may, also, constitute in itself the sole disease, and is then a variety of scurvy, properly so called.

1. OF THE SCORBUTIC CONDITION SYMPTOMATIC OF ACUTE AND CHRONIC DISEASES.

Chronic diseases.—We meet with this decrease of the fibrin in certain cases of anæmia, of Bright's disease, dropsy, and disease of the heart. Of each of these a passing notice is requisite, since the frequency with which this decrease occurs is far from being the same in all these affections.

A. *Anæmia.*—In eight cases of anæmia the fibrin fell below 2, on one occasion only.

B. *Bright's disease.*—In fifteen cases of the acute, and thirteen of the chronic form, it fell below 2 but once.

C. *Dropsy by decrease of the albumen.*—In eleven acute cases the fibrin twice fell below 2 : it did so likewise in twelve cases of cachectic dropsy.

D. *Diseases of the heart.*—It is in these affections, more especially, that the fibrin tends to diminish. Thus, in fifteen cases during the first stage, the fibrin fell below 2 on three occasions ; in twenty-three cases during the second stage it fell five times, and in thirty-one cases during the third stage it fell twelve times below 2. Thus in these sixty-nine cases, the fibrin was diminished to a considerable extent in twenty. There are some other diseases in which a consecutive diminution of the fibrin likewise takes place: such, for instance, as constitutional syphilis, old cerebral affections, old standing paraplegia when approaching to a fatal termination. We can but mention the fact, not having been enabled to make an analysis of the blood in these cases; an examination of the symptoms, however, proves almost to demonstration that such decrease actually occurs.

Acute diseases.—There are certain acute diseases in which the fibrin is invariably diminished. It is necessary, however, to add, that in these affections the decrease of the fibrin takes place only under twofold circumstances: 1. When these acute diseases have become protracted: as occurs frequently in typhoid fevers and in prolonged suppuration. 2. In certain special forms of acute disease: such, for instance, as the hæmorrhagic varieties of scarlatina, measles, small pox, and typhoid fever. Lastly, it may be proper to institute a separate division, which shall include yellow fever and certain forms of ague. The blood, it is true, has not been analysed in these diseases, but the phenomena which they present, authorize us to presume that the decrease of the fibrin is considerable.

The characteristics of this symptomatic scorbutic condition are twofold: 1. The occurrence of hæmorrhage on the surface of mucous membranes or under the skin; 2. a marked debility of the functions in general. These are facts upon which it is needless to insist.

2. IDIOPATHIC SCORBUTUS (SCURVY).

In a certain number of clearly marked cases, which are happily far less common than formerly, the decrease of the fibrin is the starting point and essence of the disease, constituting, in short, its anatomical element.

This modification of the fibrin is not always the same; and the different results afforded by analysis of the blood in this disease, necessitate the establishment of a triple distinction in regard to its anatomical element.

If, for instance, we take a certain number of individuals affected with what has been termed *scurvy*, and study the combination of phenomena by which this condition is revealed, we find its symptomatic expression to be distinctly twofold.

A. Acute scurvy;

B. Chronic scurvy.

We do not conceive it necessary to dwell at length upon the symptomatology of this disease, a full description of which may be found in treatises on pathology. But the important point to be elucidated is this, viz., whether these two forms of the affection, the acute and chronic, correspond to one and the same modification of the blood. We possess but insufficient materials for a full resolution of this problem, nevertheless we conceive that an approach to it may be made, by means of a few analyses which we have actually achieved.

A. *Acute scurvy.*—In acute scurvy, the blood presents no appreciable modification. Hæmorrhage occurs in different parts of the subcutaneous tissue and of the mucous membranes; the patients are much debilitated; wandering contusive pains are felt in the limbs, and yet the proportion of globules, albumen and fibrin may not undergo any change—they merely oscillate within the limits of health; nay, more, in some cases the fibrin is even greatly increased in quantity. Some change, however, must have taken place, whether in its texture or in its physical proportions, since it allows the blood to escape through the parietes of the capillaries—a phenomenon which does not occur in health. To explain this, it has been asserted that the proportion of soda is increased, and that this increase tends to produce a more ready solubility of the fibrin, which, becoming thus more fluid and less coagulable, permits the transudation of the blood. Without doubt, this is sometimes the case; and we willingly admit, that whenever the blood is found more fluid and less coagulable than usual, while the fibrin remains within its physiological limits, there is of necessity an increased proportion of soda in the blood, the consequence of which is, a physical change in the fibrin itself.

But can we in truth assert this to be the case, when the fibrin is found either increased in quantity or within the limits of health, and when the blood itself coagulates easily and naturally?

An increased proportion of soda in the blood has not yet been demonstrated, nor are we aware of any positive or irrecusable marks by which to recognize such a condition; albeit we must feel constrained to admit its existence, as bearing a direct relation to the well-known etiology of many cases of acute scurvy (viz., exclusive use of salted food), and to the equally well-known therapeutic efficacy of the acid treatment. We shall, however, shortly return to this subject.

The following facts, of which we are in possession, sufficiently demonstrate the nature of those modifications which the blood undergoes in acute scurvy.

It is now about six years since we read a paper before the Academy of Sciences, relative to the composition of the blood in six female patients of the Salpetrière, affected with the acute form of the disease in question.

In three of these cases the fibrin was found to have exceeded its physiological limits; in the remainder it had undergone no change.

Since then we have met with two additional cases, and we subjoin the analysis of the blood in each.

Analysis of 1000 *grammes of blood.*

In a man forty-eight years of age, affected with sub-acute scurvy of six weeks duration.

Specific gravity	1050.30
Water	786.80
Globules	142.82
Solid matters of the serum	67.88
Fibrin	2.50

Analysis of 1000 *grammes of serum.*

Specific gravity	1025.53
Water	920.00
Albumen	64.80
Extractive matters and salts	14.40

Analysis of 1000 *grammes of blood.*

In a man twenty-one years of age, affected with acute scurvy of one month's duration; the disease having commenced in the gums.

Specific gravity	1057.75
Water	783.75
Globules	125.05
Solid matters of the serum	89.00
Fibrin	2.20

Analysis of 1000 *grammes of serum.*

Specific gravity	1031.60
Water	898.40
Albumen	89.66
Extractive matters and salts	11.90

In both of these cases, the fibrin stood at its lower physiological limit; the disease, however, evinced a tendency to pass into the chronic stage.

B. *Chronic scurvy.*—In this form of the disease, matters assume a very different aspect. The fibrin is invariably modified, and this modification consists in a decrease, analogous to that which occurs in the scorbutic condition, symptomatic of certain chronic diseases. Whether the increase of the soda takes place contemporaneously with the decrease of the fibrin, we cannot say: it is possible—nay, more, it is probable; but demonstrative evidence of the fact is wanting.

We here append the analysis of the blood in two cases of chronic scurvy, in one of which, venesection was performed twice.

Analysis of 1000 *grammes of blood.*

In a man thirty-two years of age, affected with chronic scurvy of fifteen months duration, cause unknown.

Specific gravity of the blood	1060.33
Water	763.54
Globules	152.97
Solid matters of the serum	81.69
Fibrin	1.85

Analysis of 1000 *grammes of serum.*

Specific gravity of the serum	1026.22
Water	909.55
Albumen	75.84
Extractive matters and salts	14.61

Analysis of 1000 *grammes of blood.*

In a man twenty-three years of age, who had recently quitted the marines, and was affected with chronic scurvy of eighteen months duration.

	Before treatment.	Two months after treatment.
Specific gravity of the blood	1061.46	1059.88
Water	765.93	778.05
Globules	176.21	135.79
Solid matters of the serum	56.54	84.02
Fibrin	1.32	1.14

Analysis of 1000 *grammes of serum.*

Specific gravity of the serum	1020.61	1029.10
Water	931.24	902.40
Albumen	57.61	85.62
Extractive matters and salts	11.15	12.24

The most remarkable features in these two cases are the following: 1. The exceedingly large proportion of globules previous to treatment, and their decrease in the second case, after a two months' course of acids, with proper regimen; 2. In the second case, the small proportion of albumen before treatment, and its subsequent increase; due, in all probability, to the tonic regimen and generous wine that had been administered.

Practical Consequences deducible from the Modifications of the Blood in the Treatment of Scurvy.

A knowledge of the composition of the blood undoubtedly throws light upon the treatment of scurvy. In considering the subject, however, it is necessary to bear in mind the twofold division of the disease—viz., the acute and chronic.

A. *Acute scurvy.*—The normal or even increased proportion of fibrin, and the, often, large amount of globules, would seem to justify a therapeutic measure, long since fallen into disuse, but which certainly met with a tolerable amount of success. It consists in the employment of one or two general bleedings at the commencement of the disease. Lind and Sydenham had already recommended it in these cases, as does likewise M. Cruveilhier, in his *Traité d'Anatomie pathologique.* In those cases of acute scurvy which supplied the specimens of blood of which we have given an analysis above, M. Fauvel, of the Salpetrière, found this measure to be attended with good results; while we also have had reason to congratulate ourselves on its employment. In almost every instance, the bleeding—which was, moreover, often called for by the general condition of the patient—produced a marked improvement in the symptoms.

After venesection, rest, a well-directed regimen, and especially the acid treatment, constitute the best method of combating the disease.

B. *Chronic scurvy.*—Here, in addition to strict hygienic measures,—which are, however, of great consequence,—the most successful method of treating the disease consists in the administration of acids.

This method comprises the use of the vegetable acids, in every shape: citric, tartaric, and acetic acids; or, rather, the employment of those fresh vegetables which contain these acids in considerable quantity; and its efficacy is easily explained, upon the supposition of an increased proportion of soda existing in the blood.

Thus, all vegetable acids introduced into the stomach, with the exception of the oxalic, are absorbed and pass into the blood, where they are burnt and thrown out of the system, along with the urine, in the form of carbonic acid combined with the soda of the blood—*i.e.*, as carbonate of soda. The effect, therefore, of the introduction and combustion of the vegetable acids, is the formation of carbonate of soda, which is eliminated by the kidneys, and thus a certain amount of soda is removed from the blood.

If, then, scurvy consists in an increased proportion of the soda of the blood, the use of the vegetable acids must tend to remove the disease, since it abstracts the excess of the very principle which constitutes it. We were therefore justified in stating, that the successful result of treatment, and the explanation given of the same, were, up to the present time, the strongest reasons for admitting the theory respecting the increase of the soda.

It must not, however, be supposed that the treatment of the disease by acids invariably meets with success: thus, in one of the cases where we analyzed the blood, two months of such treatment produced not the slightest amelioration in the symptoms, nor any increase in the proportion of the fibrin; it merely increased the albumen and diminished the globules; and we might reasonably ask, whether this was not the result of the hygienic measures to which the patient was subjected, rather than of the acid treatment, which was nevertheless strictly carried out?

M. Hérard has recently communicated to the Academy of Medicine a case of *febrile hæmorrhagic purpura*, observed at the Hôpital de la Pitié.

The following is the case, as reported by M. Hérard:

"A man, aged thirty-five years, by trade a gilder, entered "the Hôpital de la Pitié on the 22nd of August, 1851.

"Habitually in the enjoyment of good health, endowed with "a good constitution, and of a sanguine temperament, this "man had lately recovered from an attack of erysipelas of the "face.

"On the 19th of August he was seized, on emerging from a "cold bath, with a shivering fit, followed by fever, cephalalgia, "and severe lumbar pain. These symptoms continued up to "the 22nd of the month, when he came to the hospital on "foot: the lumbar pains had become more severe, and the "febrile symptoms more marked; here and there, upon the "face and limbs, a few small conical pimples caused a suspicion "of variola.

"On the 23rd but little change had taken place; the face "and anterior regions of the thorax, however, presented an "uniform redness, without elevations, and disappearing upon "pressure. Towards evening the colour increased in intensity.

"On the 24th the cephalalgia, and especially the lumbar "pains, were still very severe; the conjunctivæ were the seat "of large violet-coloured ecchymoses; numerous petechiæ, "resembling wine lees, had appeared on the abdomen and "lower extremities; upon these latter, moreover, was noticed "a bluish tinge, occurring in patches, indicative of deep-seated "hæmorrhage. The gums were healthy, as was also the "pharyngeal cavity; the patient expectorated bloody mucus "five or six times a day, and said that he had passed urine "tinged with blood. (V.S. ad ℥vj.) Immediate relief was "afforded by the bleeding, but after a few hours the patient "complained of a sense of suffocation, and died suddenly."

Examination of the blood drawn during life.—The following are the results of a qualitative and quantitative analysis, as made shortly after death.

The blood did not, as usual, separate into serum and clot: it retained during twenty-four hours a blackish hue and a remarkable degree of fluidity, and presented no trace of the buffy coat.

Fibrin.—After the blood had been well beaten for a quarter of an hour with an osier wand, it was found impossible to detect the smallest quantity of fibrin.

Globules.—The same difficulty was experienced in separating the globules from the fibrin. It could be achieved neither by refrigeration, by spontaneous deposition, nor by the addition of sulphate of soda to the serum.

Density.—The density of the blood thus modified, was found to be 1053.56.—1000 parts when dried contained 803.44 of water, and 196.56 of solid matters.

The proportion of alkaline constituents could not be determined.

SECT. III.—Of Hæmorrhage due, in all probability, to some Modification of the Blood, not as yet ascertained.

There are certain cases of hæmorrhage which are probably the result of some alteration of the blood hitherto undetermined. Thus, for example, those hæmorrhages which have been termed *supplementary* or *vicarious*, occurring subsequent to the suppression, either of the catemenial flow or of other habitual sanguineous discharges, are in all probability due to an alteration of the blood produced by this suppression.

Critical hæmorrhages may likewise be included in the same category. There is also another variety of hæmorrhage, termed *constitutional*, depending upon a special condition of the system, and in virtue of which, hæmorrhage may occur again and again to a considerable extent. Examples of this kind are sufficiently numerous, and yet hitherto, no analysis of the blood has been made in such cases. It must be understood that we do not here allude to scorbutic hæmorrhage.

In speaking of these different forms of hæmorrhage, we do so rather with a view of pointing out the researches which require to be made, than of defining the actual state of science, which is by no means settled with respect to the subject in question.

There is one variety of hæmorrhage in which the existence of a modified condition of the blood is still very doubtful, we allude to *cerebral hæmorrhage.*

Cerebral hæmorrhage is sometimes the result of local change. Thus, softening of the brain diminishes the resistance of the walls of the cerebral vessels, which, no longer receiving the support usually afforded by the nervous tissue surrounding them, readily undergo laceration, and hæmorrhage is the result.

When there exists an ossification of the walls of the cerebral vessels, it is by no means uncommon to meet with hæmorrhage resulting from their rupture. The coincidence of softening of the cerebral matter with ossification of the vessels, tends still further to produce this result.

But putting all local conditions out of the question, there are many cases of cerebral hæmorrhage for which no special cause can be assigned, and to account for which, it has been deemed necessary to presuppose some modification of the blood.

The modification of the blood, presumed to exist in these cases, is an increase of the globules, without a corresponding increase of the fibrin; the consequence of which is a relative decrease of this latter constituent, and a greater facility of transudation on the part of the blood.

The above theory has not been very energetically maintained, *Fibrin.*—In two cases it rose above 4; in five cases it ranged between 3 and 4; in four others between 2 and 3; in one case only did it fall below 2. It is evident therefore from these figures, that the proportion of fibrin did not materially differ from that of health.

Albumen contained in 1000 *grammes of serum.*—In five cases it rose to 80 per 1000; in five others it ranged between 70 and 80; and in two others between 60 and 70. Here again the proportions are normal.

To sum up, then, we may say that in persons lately affected with cerebral hæmorrhage, the only change in the composition of the blood, consists of a marked increase of the globules. This increase is sometimes very considerable (in two cases the proportion was 177), and actually appears to precede the hæmorrhage.

We would ask, what other part does this modification of the blood play? Is it an insignificant fact,—a mere coincidence? This is barely probable, and the results of our analyses are too decided and invariable to permit of such a conclusion.

We must be satisfied therefore with pointing out the fact, without attempting its explanation.

Practical Consequences to be drawn from the Analysis of the Blood, in Cases of Cerebral Hæmorrhage.

In persons who are the subjects of cerebral hæmorrhage, it is evident, from the facts which we have just considered, that there exists a two-fold modification of the blood, usually occurring simultaneously.

The first of these consists in an augmentation of the whole mass of the blood—viz., plethora. The second, in an increase of the globules, which is often very considerable. Now, a knowledge of these facts is not a matter of indifference; it justifies the use of bloodletting in this disease, inasmuch as general bloodletting has precisely the effect of modifying these two conditions of the blood—*i.e.*, of diminishing the mass of circulating fluid, and the proportion of globules. It is scarcely possible, therefore, to believe that two such modifications of the blood, either preceding or accompanying cerebral hæmorrhage, should not exercise some influence upon its production.

This remark is especially needful, inasmuch as many practitioners regard bloodletting as utterly useless in cerebral hæmorrhage, and for two reasons: first, because, say they, the blood has undergone no change; and secondly, because the hæmorrhage having once taken place, no subsequent bloodletting can remove the effused fluid.

To these objections, the above analyses constitute a ready response. In truth, the blood *has* undergone a change, the proportion of globules being considerably increased. This being the case, bloodletting is distinctly indicated. Such is our answer to the first objection.

As for the second, it is true that hæmorrhage having once occurred, bloodletting will not cause the removal of the effused fluid; but it may prevent a consecutive increase of the sanguineous effusion—an event by no means of rare occurrence. Lastly, these analyses enable us to answer a third objection, made by those who, believing that there exists, previous to the hæmorrhage, a diminution in the proportion of fibrin, which facilitates the exudation of blood into the cerebral substance, regard bloodletting as tending still further to reduce the fibrin, and thus to favour the tendency to sanguineous effusion. Such a view is, however, no longer tenable; for so far from a decrease of the fibrin being the cause of cerebral hæmorrhage, and constituting a bar to the employment of bleeding in this affection, the analyses quoted above, indicate an increase rather than a decrease of the fibrin.

3. CEREBRAL HÆMORRHAGE OF ANCIENT DATE.

Individuals who have, for some length of time, been the subjects of hemiplegia, symptomatic of cerebral hæmorrhage, constitute no exception to the laws which regulate the composition of the blood in chronic disease, characterized as it is by a decrease in the proportion of globules, the other constituents of the blood remaining unaltered.

We subjoin the mean results afforded by the analysis of the blood, as made in five patients (three males and two females) affected with cerebral hæmorrhage, dating as follows: in two cases, three months back; in two others, four months; and in one, seven months.

Table of the composition of the blood in five cases of cerebral hæmorrhage of several months date.

Analyses of 1000 *grammes of blood.*

	Mean.
Specific gravity of the blood	1053.52
Water	808.79
Globules	112.85
Solid matters of the serum	75.16
Fibrin	3.20

Analysis of 1000 *grammes of serum.*

Specific gravity of the serum	1025.32
Water	915.48
Albumen	73.67
Extractive matters and salts	11.85

From these results, we may draw the following practical conclusion: that bloodletting should be very sparingly employed in all cases where upwards of six weeks have elapsed since the occurrence of the hæmorrhage.

ARTICLE VII.

OF THE BLOOD IN ANÆMIA AND CHLOROSIS.

We shall examine these diseases separately, and then institute a comparison between them, in order to ascertain their analogies and differences.

SECT. I.—Anæmia.

While regarding the term *anæmia* as improper, we shall yet continue to employ it, as synonymous with that modification of the blood which is characterized by a marked decrease in the proportion of the globules.

Thus interpreted, anæmia constitutes an important element of many other diseases; such, for instance, as chlorosis, Bright's disease, organic affections of the heart, etc. We shall pass these over for the present, inasmuch as we have devoted a separate chapter to each, in a subsequent portion of this work.

These diseases having been separately investigated, we shall proceed to examine the results of an analysis of the blood, as made in ten cases of symptomatic anæmia.

General result of the analyses.—The specific gravity of the blood is much lower than usual; the globules are in very small proportion, the mean being 100.12; the solid matters of the serum do not vary; the fibrin is increased.

Table showing the mean composition of the blood in ten cases of symptomatic anæmia.

Analysis of 1000 *grammes of blood.*

	Mean.	Maxima.	Minima.
Specific gravity of the blood	1049.93	1057.91	1045.01
Water	822.41	...	...
Globules	100.12	109.04	81.89
Solid matters of the serum .	73.75	88.11	69.27
Fibrin	3.72	5.82	1.62

Analysis of 1000 *grammes of serum.*

	Mean.	Maxima.	Minima.
Specific gravity of the serum	1026.82	...	...
Water	908.83	...	...
Pure albumen . . .	78.86	89.28	66.06
Extractive and fatty matters	12.29	15.05	7.00

Of these ten cases, six were males and four were females.

Ages.—One individual was below twenty years of age; five between twenty and forty; three between forty and fifty.

Causes.—In three of these cases the anæmia was the result of insufficient food, privations, misery, etc.; in three others it was due to an abundant hæmorrhoidal discharge. In one it followed a severe post-partum hæmorrhage; in another it accompanied malignant disease of the liver; in a third it followed a uterine catarrh; and in the last case no appreciable cause could be detected.

The proportion of the principal constituents of the blood was as follows.

The globules.—These were represented on seven occasions by numbers varying from 100 to 110, and from 80 to 90 on three others. In round numbers they were as follows: twice, 109; once, 107; twice, 106, 103, 100, 89, 86, and 81.

The fibrin.—Its proportions were considerable, except in one case, where it fell as low as 1.62. This was in a man who had long suffered from privations of various kinds, and whose skin was covered with an ecthymatous eruption. Of the remaining nine cases, we find that in four the fibrin rose above 4; in three it oscillated between 3 and 4; and in two between 2 and 3.

The albumen.—Its proportions were the same as in health.

The specific gravity of the serum invariably remained within physiological limits.

SECT. II.—Chlorosis.

We regard chlorosis, in common with some other authorities, as a disease having its primitive seat and origin in the nervous system, and determining subsequent disturbance of the menstrual, digestive, and circulatory functions.

If this definition be correct, it follows that the modification of the blood in chlorosis is not an invariable or essential fact, but a secondary, consecutive phenomenon, the presence of which is not absolutely necessary in order to constitute the disease in question.

In a former memoir on the blood, we brought forward two well marked cases of chlorosis, in which no modification of that fluid could be detected. To these may be added three others, which serve to confirm our views, and to show that, in some cases of chlorosis, there is no appreciable modification of the blood.

Analysis of 1000 *grammes of blood.*

Specific gravity.	Water.	Globules.	Solid matters.	Fibrin.
*1056.00	778.20	141.80	78.20	1.80
†1060.50	776.63	139.18	80.95	3.24
‡1058.10	783.16	138.39	75.72	2.73

Analyses of 1000 *grammes of serum.*

Specific gravity.	Water.	Albumen.	Extractive matters.
*1026.10	908.90	75.85	15.25
†1027.00	905.60	75.24	19.16
‡1025.51	911.70	73.26	15.04

In spite of these facts, however, it is impossible to deny that, in the majority of chlorotic cases, the blood undergoes a change, consisting more especially of a decrease in the proportion of the globules, the amount of which is, however, very variable, and depends upon the intensity and duration of the disease.

The following table shews the mean composition of the blood in six chlorotic females, of whom two were nineteen, three were twenty-one, and one twenty-two years of age.

Analysis of 1000 *parts of blood.*

	Mean.	Maxima.	Minima.
Specific gravity of the blood	1046.37	1055.25	1035.21
Water	828.55	...	...
Globules	86.83	109.17	45.37
Solid matters of the serum .	80.27	92.88	74.16
Fibrin	4.20	5.01	3.06

Analysis of 1000 *parts of serum.*

Specific gravity of the serum	1026.16	1032.24	1025.00
Water	911.80	...	...
Albumen	76.15	91.10	74.08
Extractive and fatty matters	12.05	18.52	7.61

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* A girl eighteen years of age, of tolerable constitution. Amenorrhœa, systolic basis murmur, venous hum in the jugulars ; countenance florid.

† A woman twenty-six years of age, of good constitution. Amenorrhœa; florid countenance; venous hum in the neck.

‡ A girl nineteen years of age, of lymphatic temperament, with red hair. Amenorrhœa; florid countenance; systolic basis murmur; continuous murmur in the vessels of the neck.

The globules.—In these six cases, the decrease of the globules was considerable. In round numbers, they were represented thus: 109, 104, 102, 95, 64, and 45.

The fibrin was invariably represented by a high number—thus: 5.01, 4.50, 3.34, 3.21, and 3.06.

The albumen was found within the range of health, but frequently attained its highest physiological limits.

Sect. III.—Chlorosis and Anæmia compared.

Practical Consequences deducible from the Analysis of the Blood in Chlorosis and Anæmia.

Many pathologists regard chlorosis and anæmia as one and the same disease, and assert that between them we can discover nought but a few of the most trifling and secondary points of distinction. The minority, however, look upon these affections as differing in this, that chlorosis for the most part is developed spontaneously, whilst anæmia is invariably a consecutive phenomenon, of which the cause may always be detected. We ourselves, however, go still further, and consider the points of difference between these two morbid conditions to be so marked, that we would rather seek to discover in what they resemble one another, than endeavour to point out their differential characteristics.

We shall institute such a comparison, under seven different aspects: 1. Their causes; 2. Their mode of development; 3. Their symptoms; 4. Their physical signs; 5. The modifications of the blood; 6. Their progress and duration; 7. The therapeutic measures which they require.

We shall dwell more especially upon the first and last of these points.

1. *The causes.*—In this respect, chlorosis and anæmia present no similarity. In chlorosis, the cause is for the most part unknown. It lies in some derangement of the nervous system, in other words it is one of the neuroses, of the origin of which we are ignorant. We are acquainted, however, with certain circumstances which favour its developement, and may be re-

garded in the light of predisposing causes. Such, for instance, as: *a, age;* chlorosis occurring almost invariably between the age of 15 and 25; *b, sex;* chlorosis can only be developed in the female;* *c, mental emotion* and *anxiety* favour the occurrence of chlorosis, and sometimes indeed rapidly produce it; *d, sedentary habits* and *city life* likewise exercise a certain amount of influence over the manifestation of this disease.

In anæmia, on the contrary, the cause is evident, and a variety of circumstances may give rise to the development of this morbid condition, which is not properly speaking a disease, but a symptomatic or consecutive phenomenon. Of these causes, we may mention: *a*, age: anæmia may occur at any period of life; *b*, sex; male and female are alike liable to it; *c*, atmospheric influence: insufficient ventilation, humidity, and the exclusion of solar light, are so many causes capable of engendering the anæmic condition; *d*, alimentation, whether deficient in point of quality or quantity; *e*, profuse discharges, such as hæmorrhages, bloodletting, active and long-continued purgation, diarrhœa, increased urinary secretion, profuse suppuration, venereal excesses, masturbation, leucorrhœa, dropsies; *f*, certain forms of poisoning, such as are produced by lead, mercury, and marsh miasmata; *g*, certain cachexiæ, and more especially the syphilitic, cancerous, and tubercular cachexiæ; *h*, lastly, every acute or chronic disease of moderate duration, in which a restricted regimen has been rigidly enforced, or in which the loss of fluids has been somewhat considerable, is almost of necessity followed by a greater or less degree of anæmia.

2. *Mode of development.*—In chlorosis, the disease is developed slowly and insensibly, and its phenomena are not referrible to any appreciable cause. They usually present themselves under the form of menstrual derangement. In the majority of cases, neither the patient nor her friends can account for the development of the symptoms which may thus arise during a state of otherwise robust health.

In anæmia, the symptomatic phenomena, on the contrary, invariably manifest themselves, subsequent to the application of some evident, appreciable cause. Their intensity is in direct proportion to that of the cause itself, and their apparition follows closely upon the occurrence to which they owe their origin.

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* This assertion might be contested.

3. *Symptoms.*—In chlorosis, the disease appears to consist originally of a derangement of the nervous system, and the nervous symptoms actually predominate. The character undergoes a change, and the disposition becomes modified; young females affected by it, being often sad, morose and whimsical. Sensation is often greatly modified; cephalalgia, vertigo, ringing in the ears, neuralgia of various kinds, especially gastrodynia, and enteralgia, whether simple or complicated with gaseous distension and nervous palpitation, are of frequent occurrence. The motor powers are not unfrequently affected. Thus, the strength of the patient fails, and pains are felt in the loins and in the muscles of the extremities. In certain cases, we notice irregular muscular action constituting either chorea or hysteria. In others, the digestive organs are deranged, the appetite is depraved, and the sense of thirst increased and marked by a desire for acid drinks. Slow digestion, flatulent distension, and obstinate costiveness, are very common symptoms, and play an important part in chlorosis.

The discoloration and yellowish tinge of the skin, together with the exsanguine appearance of the mucous membranes, are frequently manifest at the very onset of the disease. Disordered menstruation, dysmenorrhœa or amenorrhœa, are frequent and almost invariable occurrences in chlorosis. The same may likewise be said frequently of leucorrhœa.

In anæmia, the physiognomy of the disease, so to speak, is for the most part essentially different; the nervous symptoms play but a secondary part, and are often entirely wanting. Debility, lumbar pain, and sometimes, when the disease is severe, cephalalgia, vertigo, and even nervous delirium, such are its sole characteristic phenomena. The neuralgiæ and neuroses are often absent, and when they do occur, they present no marked peculiarity. The digestive organs are seldom much deranged in the milder forms of anæmia. We do not observe the depraved appetite, the flatulent gastralgia and enteralgia, the constipation, etc., which are so common in chlorosis. Increased sense of thirst, however, is an important feature in anæmia, being even more marked than in chlorosis. Menstrual derangement may be entirely wanting in anæmia; when severe, however, amenorrhœa and dysmenorrhœa are both liable to occur, but they are less frequent and milder than in chlorosis.

The same may be said of leucorrhœa. We are to be understood, however, as setting aside that form of anæmia which is symptomatic of uterine disease. Palpitation and dyspnœa are more marked in anæmia than in chlorosis; they are, in fact, entirely dependent upon the amount of change which the blood may have undergone, *i.e.*, upon the decrease of the globules. We may say the same respecting the decoloration of the skin, which rarely presents the yellow tinge of chlorosis, and the intensity of which, is equally dependent upon a diminished proportion of the globules.

From the above comparative statement it is evident that, even with respect to symptoms, a marked distinction may be drawn between chlorosis and anæmia.

4. *Physical signs.*—The cardiac and vascular murmurs are often the same both in the milder forms of chlorosis and in the severe forms of anæmia. Sometimes, however, the sounds present certain special characteristics which enable us to distinguish one disease from the other.

In chlorosis, the physical signs are for the most part as follows: *a*, over the cardiac region a soft basic systolic murmur, audible in the aorta; *b*, in the vessels of the neck, an intermittent bellows murmur, having its seat in the carotids and synchronous with the first sound of the heart; *c*, a continuous humming sound, of a very different nature, situated in the jugular veins; *d*, an uninterrupted reduplicate murmur, which is merely a combination of the continuous venous hum and the intermittent carotid murmur.

In chlorosis, we sometimes find the absence of cardiac systolic bruit, to coexist with the presence of a continued murmur with or without reduplication. This may occur without any considerable decrease on the part of the globules.

In anæmia, the murmurs are somewhat different. Thus:

A. The systolic basic murmur is a *constant* phenomenon. It may exist alone, without an accompanying vascular murmur, and is the first of the physical signs afforded by the circulatory system in anæmia.

B. The intermittent carotid murmur is one of the most constant phenomena of anæmia; its development invariably succeeds that of the cardiac murmur, and its intensity is like that of the latter, entirely proportionate to the decrease of the globules.

C. The continuous venous hum is more rare; it never is heard except in cases of advanced anæmia, and when the proportion of globules is greatly below the natural standard; in a word, it depends upon the degree of modification which the blood has undergone, and this is not always the case in chlorosis. Lastly, we meet with the musical sounds less frequently in anæmia than in chlorosis.

5. *Composition of the blood.*—It was long thought (and is so still by many), that the modifications of the blood in anæmia and chlorosis were absolutely identical. The results which we have already mentioned, as afforded by the analysis of the blood in these diseases, necessitate the admission of certain differences existing between them in this respect.

A. In some cases of chlorosis, the alteration in the blood may be entirely wanting: in others, again, it exists, without however being proportionate to the amount of functional disturbance evinced by the circulatory system. Lastly, in a third class of cases there is an agreement in this respect.

In anæmia, the change in the composition of the blood is constant, and the amount of functional derangement occurring in the circulation, invariably proportionate to the degree of alteration which this fluid has undergone.

B. In *chlorosis*, the only modification of the blood, consists of a *decrease of the globules.* This is not always met with, and in some cases it would seem to be independent of the severity of the disease, while in others, that are to all appearance similar, it may be present in very different degrees. We may likewise observe, however, that there is often a direct relationship between the decrease of the globules and the intensity of the disease.

In *anæmia*, the proportion of globules, while varying greatly, always bears a direct ratio to the exciting cause of the disease, which, as we have before said, may generally be ascertained. The proportion of globules, moreover, is likewise in direct ratio to the intensity of those functional derangements, which in fact indicate this diminution on the part of the globules, and constitute the disease in question.

C. In *chlorosis*, the numerical standard of the fibrin is generally somewhat above the physiological mean. Occasionally it may rise to 5 or 6, without the slightest trace of inflammatory action.

In *anæmia*, the representative number of the fibrin, on the contrary, either falls or remains unchanged. Sometimes indeed, in severe cases, it may fall as low as 1.5.

D. In *chlorosis*, the albumen always remains within its usual physiological limits. In anæmia, the proportion of albumen is often natural, but it is not unfrequently diminished, and in severe cases the decrease may even be considerable.

6. *Course and duration.*—In neglected chlorosis, where the ferruginous preparations have not been administered, the disease often lasts for a long time. Its duration is uncertain, and we know nothing of the causes by which its course is modified. It sometimes disappears under the effect of certain moral influences, at others it does so spontaneously.

In anæmia, the course and duration of the disease are entirely subordinate to the cause to which it owes its origin. This cause once removed, it is evident that, unlike chlorosis, the affection must yield with more or less rapidity.

7. *Therapeutic treatment.*—The distinctions which we have laid down as existing between anæmia and chlorosis are of especial importance in a therapeutic point of view; and from the subjoined details it will be readily seen, that we have not

vainly insisted upon these distinctions, from which the following deductions may, we think, be made.

In chlorosis, the treatment consists in the adoption of a certain method, of which we may give the following summary.

1. *The internal use of iron.*—This is the essential point; for the physician who knows how to vary its mode of administration, so as to be easily tolerated by the stomach, the whole, or at least the greater portion, of the cure lies in the use of this remedy. In young females whose condition with respect to worldly circumstances is all that can be desired, who live in the country, breathe a pure air, enjoy wholesome nutritious diet, and labour under no depressing moral influence, the administration of iron is absolutely essential to the removal of the disease. In some cases it may undoubtedly fail, and in others the affection may obstinately continue for a length of time, with frequent relapses: these are facts which cannot be denied, but it is not the less certain that iron constitutes the sole therapeutic means capable of successfully combating the disease in question. We cannot lay too much stress upon this fact, which is not however of recently established date.

2. *A suitable diet*, comprising the use of generous wines, roast meats, etc., a healthy well-ventilated country residence; the removal of all those injurious moral influences which may be regarded as having contributed to produce the disease, may accelerate and favour the restoration of health; but taken alone, they prove comparatively inefficacious, unless iron in some shape or other be at the same time administered.

Cinchona has been and still is much employed in the treatment of chlorosis; it is a remedy upon which very great stress has been laid, but we believe it to possess no efficacy whatever. To sum up, then, the treatment of chlorosis consists: 1. In the use of iron and its salts; 2. In endeavours to modify the *morale* of the patient; 3. In the adoption of certain hygienic measures relative to diet, locality, aeration, etc.

The therapeutic treatment of anæmia, however, reposes on a different basis from that of chlorosis. Thus, in the former, the first indication to be fulfilled is the destruction or removal of the exciting cause. But as we have before stated that the cause of anæmia can always be ascertained, it follows either that this cause does not admit of removal and that the disease consequently is incurable, or that, having been produced by certain previous diseases which are amenable to treatment, the resulting anæmia may likewise be cured; in such cases, the first thing to be done,—in fact we were about to say the only thing to be done,—is to remove the cause. We may conclude therefore by saying, that the principal therapeutic indication in the treatment of anæmia, is to obtain a removal, or at least a mitigation, of the cause to which it owes its origin.

In some of these cases the removal of the cause will alone suffice for the cure; as, for instance, when the disease is the result of insufficient nourishment or of uterine catarrh. In this latter case, there is heard, during the whole course of the affection, that peculiar bellows murmur, with the first sound of the heart, symptomatic of that change of the blood which constitutes the anæmic state. Frequently, indeed, are most persevering attempts made to combat this condition by the use of iron, and much astonishment is produced at the failure which ensues; whilst if the uterine catarrh itself be removed, the murmur will vanish spontaneously.

But while adopting this plan of treatment, which, as we have seen, is not always practicable, it is not the less necessary to have recourse to other therapeutic measures.

Here, however, we find an important distinction between anæmia and chlorosis. Thus, the preparations of iron, for instance, which play such an important part in the treatment of the latter disease, are of much less value in that of the former. We do not indeed pretend to deny that, in certain cases of anæmia, symptomatic of severe hæmorrhage, the preparations of iron are absolutely useless, but their utility is only secondary to the employment of hygienic measures.

In symptomatic anæmia, hygiene is of primary importance, whether the cause of the disease be capable of removal or not. A pure healthy atmosphere, an elevated locality, residence in the country, tonic regimen, the use of roast meats, strong broths and generous wines, proper exercise, a sufficient amount of sleep, and an absence of moral disquietude; such are the hygienic conditions, which mainly contribute to the cure of anæmia.

Cinchona—which, as we have said before, is of comparatively little value in chlorosis—succeeds far better in anæmia. This arises from the fact, that the remedy in question acts especially upon the albumen rather than upon the globules; and we have already seen that the albumen, while remaining unchanged in chlorosis, is always somewhat diminished in anæmia.

The following *resumé* of the treatment of anæmia, as compared with that which we have shown to be necessary in chlorosis, may suffice to shew the difference which exists between them in this respect.

1. Removal, destruction, or mitigation of the known cause of the anæmic condition, whenever this is possible; and—2. The employment—*a*, of certain hygienic measures; *b*, of cinchona; *c*, of iron and its salts,—but these only in certain exceptional cases, and more especially where the disease is the result of copious hæmorrhage.

ARTICLE VIII.

OF THE BLOOD IN BRIGHT'S DISEASE.

The modifications which the blood undergoes in the disease characterized by a particular lesion of the kidney, with general anasarca, as first described by Dr. Bright, have been made the subject of special research by Gregory, Bostock, Christison, and more recently by MM. Andral and Gavarret.

A diminished proportion of albumen, and a consequent decrease in the density of the serum,* constitute the leading facts resulting from the analyses of these authorities, and from them has been rightly deduced the pathogenesis of the dropsy usually developed under such circumstances. The escape of the albumen along with the urine impoverishes the serum, which transudes with increased facility through the walls of the capillaries, by reason of its low specific gravity, and thus constitutes dropsy.

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* The accumulation of urea in the blood is still a very questionable phenomenon.

The various questions which arise in connexion with the modifications of the blood in this affection, are far from being as yet satisfactorily settled. In fact, so few analyses of this fluid have hitherto been made, that we are fairly entitled to put the following questions.

1. Is the decrease of the albumen a constant occurrence? 2. Does it take place alike in the acute and chronic form of the disease? 3. Is the amount of decrease always the same? 4. By what circumstances is it modified?

Having analyzed the blood in twenty-eight cases of Bright's disease, we conceive it possible to answer these questions in a satisfactory manner.

SECT. I.—Acute Bright's Disease.

Under this denomination we include a certain number of cases, of which the following are the chief characteristics.

In an individual, usually strong and healthy, the following symptoms are found to arise with considerable rapidity, either spontaneously, or as the result of the application of cold: viz. lumbar pain, acceleration of the pulse, and general dropsy, of the kind formerly designated as acute or active. There is often, moreover, a burning heat of skin, and acute bronchitis. Lastly, we invariably find the urine of a dark colour, strongly acid, often loaded with altered blood globules, and especially with albumen. This condition is usually of but short duration: it either terminates favourably, under the influence of treatment, or passes into the chronic stage. It is almost superfluous to add, that this combination of symptoms corresponds to that anatomical condition of the kidneys to which we give the name of hyperæmia, or congestion. Such is the acute form of Bright's disease.

We have collected fifteen of such cases, in which an analysis of the blood, made with the utmost accuracy and caution, gave the following results.

The amount of albumen contained in 1000 parts of serum undergoes marked, but different, degrees of diminution: this diminution is usually greater in proportion to the time which has elapsed since the commencement of the disease, being scarcely perceptible before the third day. As a consequence of this decrease, we must further notice the diminished density of the serum, which is in direct proportion to the decrease of the albumen. The amount of fatty and extractive matters is somewhat larger than usual. It is in the acute form of Bright's disease that we have most frequently* met with that special condition of the serum, to which the term milky serum has been applied. Analysis has shewn us that this lactescence is not due to the presence of fatty matter in a state of suspension, but to a particular condition of the albumen, which exists, if we may so speak, in a globular form.

It is important to notice that, after the cure of the disease, the serum remains for a length of time in a state of impoverishment; and that even when eight or ten days have elapsed since the disappearance of the albumen in the urine, it does not reappear in proper quantity in the serum, for some time afterwards.

Table shewing the mean composition of the blood in fifteen cases of the acute form of Bright's disease.

Analysis of 1000 *grammes of blood,*

	Mean.	Maxima.	Minima.
Specific gravity of the blood	1048.27	1058.80	1037.42
Water	814.42	...	...
Globules	117.28	146.52	85.50
Solid matters of the serum .	65.31	76.53	55.15
Fibrin	2.99	3.76	1.65

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* Twice in fifteen cases.

Analysis of 1000 *grammes of serum.*

	Mean.	Maxima.	Minima.
Specific gravity of the serum	1023.55	1030.00	1016.50
Water	925.66	...	...
Albumen	60.58	71.00	49.32
Extractive matters, fatty matters, and salts . .	13.76	21.95	9.58

Of these fifteen cases, seven were males and eight females. Their ages were respectively as follows: two were under thirty years of age, four between thirty and forty, five from forty to fifty, and four were upwards of fifty years of age.

The cause of the disease was not always distinctly appreciable. Thus, in eight cases the symptoms arose subsequent to the application of cold; in one case, during convalescence from scarlatina; in another, after a sudden suppression of the menses; lastly, in five cases no evident cause could be traced.

The duration of the disease, previous to bloodletting, varied. In two cases it had lasted five days; in two others, eight days; in seven, from eight to fifteen days; and in four, from fifteen to thirty days.

In six cases the disease was accompanied by feverish symptoms; the remaining nine were free from such symptoms on their admission into the hospital.

Nine of the cases were cured, two passed into the chronic stage, two left the hospital after a few days, without being completely cured, one died of cholera, and another of double pneumonia.

The chief constituents of the blood were found to have undergone the following changes.

The globules.—In one case the representative number of the globules was above 140, in three cases from 130 to 140, in six from 120 to 130, in two from 110 to 120, in another from 100 to 110, and in the two last it fell below 100. These figures present such variety, that nothing definite can be stated on this head; all we can say is, that in some few cases of comparatively long duration, the globules tend to decrease.

The albumen.—In two cases it rose to above 70 per 1000, in two it varied from 65 to 70, in four from 60 to 65, in two from 55 to 60, in four from 50 to 55, and in one case it fell below 50. Thus, in thirteen cases out of fifteen, the albumen contained in 1000 parts of serum was diminished. This diminution was greatest in proportion to the length of time which had elapsed since the commencement of the disease, and at the same time stood in direct relation to the dropsical symptoms. The result of this almost invariable decrease of the albumen, is a marked diminution in the specific gravity of the serum.

The fibrin retains its normal proportions; in some cases it even undergoes a slight increase: in six cases it exceeded 3 per cent. (once 6.8), in eight it varied between 2 and 3, and in another it fell as low as 1.65.

Practical Conclusions deducible from the Analysis of the Blood in the Acute Form of Bright's Disease.

The results afforded by the preceding analyses furnish certain practical data, upon which we deem it advisable to insist.

It is evident, in fact, from these analyses, that the globules and the fibrin, at the commencement of the disease, are in no way altered, and that even the albumen of the serum undergoes scarcely any modification at this early period. On the other hand, if we consider that general bloodletting acts merely on the globules, and that it must be carried to a very considerable extent, in order to produce a marked decrease of both the globules and fibrin, we shall be led to draw a very simple therapeutic deduction, and one which is perfectly applicable in the present instance. The anatomical lesion constituting the acute form of Bright's disease is congestion of the kidneys. Bloodletting is undoubtedly one of the most successful means of relieving acute congestion in general; it may therefore be employed without hesitation in this affection: nor need we apprehend its use being followed by a still further modification of the blood. Such is, moreover, the result which we have obtained in thirteen out of the fifteen cases previously quoted (two of the fifteen died from complications). The patient, on admission into the hospital, was bled from the arm once; and this was followed by the application of leeches, or the scarificator, to the lumbar region. The adoption of these measures was invariably crowned with success, being rapidly followed by a marked decrease, and even by the complete disappearance of the albumen from the urine.

We must here state, that our experience is unfavourable to the use of diuretics in this form of the disease. They for the most part increase the congestion, stimulate the kidneys, and rather favour the escape of the albumen with the urine than otherwise. The use of the vapour or hot air bath would seem to be the most suitable method of hastening the removal of the dropsy. The serum, as we have said before, remaining impoverished long subsequent to the disappearance of the albumen from the urine, it must be restored to the healthy standard by the administration of bark and its compounds, and by the use of a highly nitrogenized diet. In these cases, the preparations of iron are useless.

SECT. II.—Chronic Bright's Disease.

The changes in the kidney, characteristic of Bright's disease, may be developed slowly; and in this respect two very different cases may present themselves. In one, for instance, the chronic form may succeed an acute attack of the disease, whilst in another, it may arise slowly, insidiously, and imperceptibly, either as an idiopathic affection, or as a complication of cardiac or hepatic disease, cirrhosis, etc. etc. In whatever form it may occur, however, it is of importance to ascertain the nature of the alteration which the blood undergoes in this, the chronic variety of the disease; and whether this alteration be similar to that which we have found to exist in the acute form. With this object in view, we have analysed the blood in thirteen cases, and the following are the conclusions to which we have been thus led.

In the chronic form of Bright's disease, a great change takes place in the blood; its mean density falls from 1060 to 1045.6.

The globules fall likewise; 108.08 represents the mean of thirteen cases. The fibrin on the contrary appears to undergo a decided increase, without the intervention of inflammatory action; its mean amount being represented by the figures 4.37.

The serum likewise undergoes a considerable change; its mean is represented by 1021.83. The albumen is greatly diminished, its mean being represented by 55.93. Lastly, the extractive and fatty matters are somewhat increased; their mean being 14.50. These modifications are in general proportionate to the duration of the disease; to the amount of general dropsy; to the proportion of albumen found in the urine; and to the extent to which lowering measures have been adopted.

Table shewing the mean composition of the blood in thirteen cases of chronic Bright's disease.

Analysis of 1000 *parts of blood.*

	Mean.	Maxima.	Minima.
Specific gravity of the blood	1045.61	1056.25	1030.24
Water	832.60	...	...
Globules	108.08	136.67	52.32
Solid matters of the serum .	63.95	78.89	55.58
Fibrin	4.37	6.50	2.59

Analysis of 1000 *parts of serum.*

Specific gravity of the serum	1021.83	1026.10	1018.00
Water	929.57	...	...
Albumen	55.93	66.60	45.25
Extractive and fatty matters	14.50	24.09	8.05

Of these thirteen cases, nine were males and four females. Four were between twenty and forty years of age, five between fifty and sixty, and four had passed their sixtieth year.

The disease, in each case, had lasted at least two months, and might therefore justly be regarded as chronic. In three cases it had disappeared and returned. In the others its course had been uninterruptedly progressive.

In twelve cases there was a varying amount of dropsy. In one only was this symptom entirely wanting.

In each case the quantity of urine was much diminished; it was generally limpid, of a greenish hue, faintly acid and of low specific gravity. It was always found to contain a considerable amount of albumen, varying however in different cases.

The principal complications noticed, were as follows; in five cases there was a marked degree of anæmia, as indicated by vascular and arterial murmurs. In three others, there was organic disease of the heart; in another, bronchitis and emphysema. In the last case, the disease followed delivery.

The following modifications of the blood were noticed.

Globules.—In three cases they exceeded 130 per 1000; in one they varied from 120 to 130; in five, from 110 to 120; in two, from 100 to 110; and in two others they fell much below 100 (52.32 and 52.27).

Fibrin.—In seven cases its proportion varied from 4 to 5 per 1000; in three, from 3 to 4, and in three others, from 2.5 to 3. This increase of the fibrin deserves attention, and seems difficult of explanation.

Albumen.—The albumen contained in 1000 parts of serum was invariably diminished; in three cases its proportions were from 60 to 65 per 1000; in five, from 55 to 60; in three, from 50 to 55; and twice they fell below 50.

The specific gravity fell in proportion to the decrease of the albumen.

Practical Conclusions deducible from the Analysis of the Blood in the Chronic Form of Bright's Disease.

If there be a disease the cure of which is difficult, not to say impossible, it is certainly the chronic form of Bright's disease. A knowledge however of the changes occurring in the blood is of importance, and may serve to afford the practitioner some clue to the solution of a most difficult therapeutic problem.

We have in fact here, to consider both the changes in the kidney and the modifications of the blood, these last being in reality the cause of the dropsy and of the general deterioration of the system.

The condition of the kidneys ought not here to occupy our attention; we cannot however forbear remarking, that it is generally overlooked in the treatment of this disease. We lay much stress upon the establishment of an artificial discharge over the region of the kidneys, whether by means of the moxa or of the actual cautery. A due consideration of the local disease induces us to discountenance the administration of diuretics, as in the acute form of the affection.*

Purgatives have not struck us as being very serviceable; we have sometimes seen their employment followed by intractable diarrhœa, and premature death.

What then are the indications afforded by a knowledge of the composition of the blood in these cases?

The decrease of the globules and albumen at once forbids the employment of bloodletting: but, on the contrary, points out the necessity for iron and bark. It likewise affords an indication for the use of a highly nourishing diet and generous wines. These remedial measures ought in our opinion to be regarded as the basis of treatment in the chronic form of Bright's disease.

Dropsy is one of the symptoms, the removal of which is of the greatest consequence; the use of purgatives and diuretics should, however, as we have already stated, be avoided. We cannot, however, too strongly recommend the employment of hot-air baths, care being taken not to weaken the patient or to deteriorate the blood still further.

We may sum up then by saying, that, in the present state of science, stimulant frictions, bark, iron, and a tonic regimen, constitute the therapeutic measures which may be employed with, we will not say the greatest success, but with the least amount of failure, in the chronic form of Bright's disease.

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* A contrary opinion is entertained by several eminent authorities on this disease. Christison, etc.

ARTICLE IX.

OF THE BLOOD IN DROPSIES.

The recent progress of pathological anatomy, together with the researches made relative to the composition of the blood, during the last twenty years, have considerably modified the ideas formerly entertained respecting dropsy. The class of dropsies long regarded as idiopathic or essential, has become gradually so restricted, as almost to have disappeared from our nosological classification.

Science, however, cannot as yet be said to have pronounced its ultimatum on this head; respecting which, several questions remain undecided, as may easily be demonstrated.

Our own researches would lead us to admit only two species of dropsy.

1. The so-called mechanical dropsies, the result of an obstacle presented to the flow of blood, whether in the central organ of the circulation or in a vascular trunk of a certain size. This class is perhaps the most numerous, and we shall refer to it again shortly.

2. Dropsies symptomatic of a special modification of the blood, consisting exclusively of a decrease in the proportion of the albumen of the serum. It is with respect to the admission of certain forms of dropsy into this category, that there exists a difference of opinion among certain pathologists. A few details respecting the actual state of science, may serve to point out the question at issue.

Attention was first directed to the diminished proportion of albumen in the blood, as a cause of dropsy, by Gregory, Bostock, and Christison. They likewise noticed this condition of the blood in Bright's disease, and attributed to it the production of the dropsical symptoms.

In France, M. Rayer has laid much stress on the diminished density of the serum in this disease. MM. Andral and Gavarret have moreover confirmed, by their analyses, the fact of the decrease of the albumen in Bright's disease.

Up to this period, investigations were limited to the subject of dropsies symptomatic of an alteration of the blood. M. Andral was the first to propound the idea, in his work on *hæmatology*, that many dropsies hitherto regarded as essential, might probably be due to a modification of the blood, analogous to that which is found to exist in Bright's disease. More recently, M. Becquerel adopted this idea, and affirmed that, in the majority of cases of so-called essential or idiopathic dropsy, some modification of the blood must necessarily exist. Still more recently, M. Requin, in his *Elements of Pathology*, admits but two classes of dropsy, and adopts a similar opinion. Neither of these authors, however, were in possession of facts capable of solving the problem in question.

Two years ago we, for the first time, were in a position to bring forward such a series of facts, in a memoir read before the medical society of the Parisian hospitals. In this memoir, we shewed that certain forms of dropsy, hitherto regarded as essential, ought rather to be attributed to a decrease of the albumen of the blood. It is to this point we wish now to direct attention; and in doing so we shall consider—1. The subject of mechanical dropsy; and 2. That of dropsy depending on a decrease of the albumen of the blood.

Sect. I.—Dropsy depending upon an Obstacle to the Circulation of the Blood.

MECHANICAL DROPSY.

The obstacle to the circulation of the blood may exist in the heart, or in a venous trunk of a certain calibre.

Dropsy symptomatic of organic disease of the heart is subject to certain special laws, to which we have referred in a separate chapter. As for those cases of dropsy which are the result of venous obstruction, their species and genera are numerous; nor do we intend to dwell upon them at present. We merely wish to prove that, in these cases, there is no change in the composition of the serum.

The following cases suffice to demonstrate the truth of our proposition:

Analysis of 1000 *grammes of blood.*

	A female, aged 65; anasarca, dependent on cancer of the stomach and pancreas.	A female, aged 36; anasarca of the lower extremities, due to an abdominal tumour.	A female, aged 24; ascites and anasarca due to abdominal tumours.	A female, aged 61; anasarca, dependent upon cancer of the stomach.
Specific gravity	1057.01	1053.45	1060.75	1043 56
Water	802.79	810.20	828.30	842.40
Globules	106.23	90.30	90.02	71.37
Solid matters of the serum	80.20	85.50	86.03	81.85
Fibrin	1.78	4.00	5.55	5.38

Analysis of 1000 *grammes of serum.*

Specific gravity	1032.51	1033.00	1028.73	1026.69
Water	900.00	894.53	905.83	913.68
Albumen	73.26	82.62	76.74	70.80
Extractive matters and salts	26.74	22.85	17.33	15.68

The above analyses afford evidence of a decrease on the part of the globules, which is most probably due to the impoverishment of the blood caused by the escape of its watery portion. We are unable to account for the increase of fibrin in three of these cases, wherein no trace of inflammatory action existed.

Sect. II.—Of Dropsies symptomatic of a diminished Proportion of the Albumen of the Blood.

Dropsies included under this category may be divided into two distinct groups, comprising a variety of cases, differing greatly from one another.

First Group.—*Cachectic Dropsies.*—This group comprehends those forms of the disease which are symptomatic of a decrease on the part of the albumen, referable to some distinctly appreciable cause, sufficient in itself to explain the change which the serum has undergone. It includes several different varieties: these we shall successively pass in review.

1. *Bright's disease.*—In this affection, the escape of albumen with the urine is sufficient to account for its decrease in the

blood. This subject we have already treated of in a separate chapter.

2. Dropsies occurring as the result of *insufficient nourishment, privations*, etc. Of this kind we subjoin two examples:

Analysis of 1000 *grammes of blood.*

	A man, aged 60; weakened by want and suffering from dropsy, not referrible to any appreciable organic cause.	A man, aged 64; suffering privations of every kind, labouring under cachectic dropsy.
Specific gravity	1051.10	1031.05
Water	825.94	876.82
Globules	101.96	64.96
Solid matters of the serum	68.50	55.04
Fibrin	3.60	3.18

Analysis of 1000 *grammes of serum.*

Specific gravity	1025.10	1020.51
Water	923.50	937.86
Albumen	65.43	51.30
Extractive matters and salts	11.07	10.84

In the above cases, two of the chief constituents of the blood were diminished. In one the globules fell to 101; in the other to 64. The albumen of the serum fell to 65.43 in one case, and to 51.30 in the other. The density of both blood and serum decreased in a similar ratio.

3. *Hæmorrhages* of long duration, but of moderate severity,—such, for instance, as the hæmorrhoidal flux,—tend to produce a decrease on the part of both the albumen and globules: in such cases the dropsy is associated with cardiac and vascular murmurs.

Analysis of 1000 *grammes of blood,*

In an anæmic male affected with an incessant hæmorrhoidal flux of three months duration.

Specific gravity	1041.04
Water	888.24
Globules	47.00
Solid matters of the serum	62.50
Fibrin	2.26

Analysis of 1000 *grammes of serum.*

Specific gravity	1023.03
Water	923.00
Albumen	61.40
Extractive matter and salts	15.60

The decrease of the globules in this case is very marked.

4. *Chronic diarrhœa,* when associated with much general functional disturbance, or with chronic enteritis, sometimes occasions anæmia and dropsy. This latter phenomenon is explained by the diminished proportion of the albumen of the serum. Of this form of dropsy, we subjoin three examples:

Analysis of 1000 *grammes of blood.*

	A woman, aged 26; labouring under cachectic dropsy, following chronic diarrhœa.	A man, aged 58; suffering from anæmia and cachectic dropsy, following chronic diarrhœa.	A woman, aged 25; suffering from anæmia, chronic diarrhœa, and cachectic dropsy.
Specific gravity	1043.55	1043.82	1045.01
Water	864.45	847.28	824.55
Globules	83.63	90.84	103.52
Solid matters of the serum	49.88	59.87	68.20
Fibrin	2.04	2.01	3.73

Analysis of 1000 *grammes of serum.*

Specific gravity	1027.75	1023.89	1023.35
Water	946.55	935.13	923.63
Albumen	45.61	53.38	64.05
Extractive matters and salts	7.84	11.49	12.35

These analyses shew a simultaneous decrease of the albumen and globules. The specific gravity of the blood and serum fell in proportion to this decrease.

5. *The cancerous diathesis.*—The cancerous diathesis almost invariably produces a modification of the blood, which, for the most part, lies in a decrease of the globules. Sometimes, however, it determines a decrease of the albumen, which is in turn followed by a variety of cachectic dropsy. We must not be understood as alluding here to those cases of dropsy which are caused by the pressure of a cancerous tumour upon a large venous trunk, as this form of the disease comes under the head of mechanical dropsy.

Analysis of 1000 *grammes of blood,*
In a man labouring under cancer of the stomach and general dropsy, the result of the cancerous cachexy.

Specific gravity	1034.13
Water	879.54
Globules	54.20
Solid matters of the serum	63.83
Fibrin	2.42

Analysis of 1000 *grammes of serum.*

Specific gravity	1023.32
Water	938.09
Albumen	60.81
Extractive matters and salts	11.10

6. *Marsh cachexy.*—Under the influence of the marsh poison, we often notice the development of that peculiar condition to which the term marsh cachexy has been applied. This condition is accompanied by a remarkable decoloration of the skin, and not unfrequently by dropsy. This latter symptom has been, indeed, attributed to the mechanical obstacle afforded by the enlarged condition of the spleen, so common in these cases. We do not deny the possibility of such a sequence, but it is certain that, in many instances, we fail to discover such an amount of splenic enlargement as would suffice to explain the occurrence of an increasing and general anasarca. We subjoin the analysis of the blood in five cases of marsh cachexy, in one only of which did we notice a marked degree of splenic enlargement: it was, however, insufficient to account for the serous infiltration present.

Analysis of 1000 *grammes of blood.*

	A man, aged 50, suffering from marsh cachexy and general dropsy.	A man, aged 48, suffering from marsh cachexy and general dropsy.	A man, aged 48, suffering from marsh cachexy and general dropsy.	A man, aged 23, suffering from marsh cachexy and general dropsy.	A man, aged 18, suffering from marsh cachexy and general dropsy.
Specific gravity	1035.40	1040.00	1034.06	1033.85	1040.51
Water	869.34	853.75	869.71	875.67	846.31
Globules	67.10	101.87	67.28	56.22	87.22
Solid matters of the serum	61.10	41.84	59.88	63.83	62.32
Fibrin	2.36	2.54	3.13	4.27	4.15

Analysis of 1000 *grammes of serum.*

Specific gravity .	1020.37	1016.40	1021.61	1024.15	1023.56
Water . . .	936.40	953.29	930.08	926.75	922.98
Albumen . .	55.68	37.26	50.20	60.20	63.25
Extractive matters and salts . .	7.92	9.45	13.72	13.05	13.77

In these five cases, the modifications of the blood are very similar. The mean composition of the blood, therefore, in marsh cachexy, may be thus represented:

Analysis of 1000 *grammes of blood (mean composition of, in five cases).*

Specific gravity	1036.76
Water	962.38
Globules	75.94
Solid matters of serum	57.79
Fibrin	3.39

And the mean composition of 1000 *grammes of serum, as follows:*

Specific gravity	1021.22
Water	935.10
Albumen	53.32
Extractive matters and salts	11.58

It is in this disease, therefore, that we meet with the greatest decrease on the part of both the albumen and globules. It may be taken as the type of cachectic dropsy.

How, now, are we to account for so great a change in the composition of the blood?—We are driven to admit a poisoned condition of this fluid, produced either by the absorption of the marsh miasm, or by repeated attacks of the peculiar fever to which this miasm gives rise.

Such are the principal forms of cachectic dropsy which have come under our own observation, in addition to that which is the result of Bright's disease. The mean composition of the blood in these different forms of dropsy, affords the best *resumé* of the entire subject that we can offer.

Mean composition of the blood in cachectic dropsies generally.

Analysis of 1000 *grammes of blood.*

Specific gravity	1039.66
Water	939.85
Globules	76.67
Solid matters of the serum	60.48
Fibrin	3.00

Analysis of 1000 *grammes of serum.*

Specific gravity	1022.67
Water	932.65
Extractive matters and salts	11.40
Albumen	55.95

The above analysis suggests various reflections. We must first remark that, in all the different varieties of cachectic dropsy, the albumen does not decrease *per se;* there is a simultaneous and invariable diminution of the globules.

To what degree then, we may ask, must the albumen of the blood fall, in chronic disease, in order to give rise to dropsy, by reason of the low specific gravity of the serum? An examination of the facts, together with the mean results given above, permit us to fix upon 60 as the point at which dropsy may occur, and we may add that in proportion as the albumen falls below this point (60 parts per 1000), will the dropsy tend to increase.

SECOND GROUP.—*Acute Dropsy.*—In spite of the progress of pathological anatomy and of modern chemical discovery, we not unfrequently observe, whether in hospitals or in private practice, certain cases of dropsy to which we are obliged to apply the term essential. These are for the most part acute, no trace of albumen is found in the urine, and their dependance upon some alteration of the blood has, as yet, been merely proved by induction. We have made an analysis of the blood in eleven cases of this description.

Of these we shall now give an historical *resumé,* in order to enable the reader to judge of the nature of the dropsy in question. Nine of the patients were males, and two were females. In all, the disease set in rapidly under the following circumstances.

In one case it followed a sudden suppression of the catamenia from violent emotion; in a second, it occurred at the fifth month of pregnancy, but without any very appreciable cause; in a third, it followed an attack of scarlatina; in four other cases it followed prolonged exposure to cold; in another, it resulted from sleeping on the ground in the open air during the month of June; lastly, in three cases the cause was inappreciable. In two of these latter, the patients were suffering from a relapse of the disease.

Of these eleven patients, none entered the hospital before the fourth or after the eleventh day of the disease.

The primary phenomena were not the same in every case. In six, dropsy was the only symptom; in two, it was accompanied by fever; in two others, there was likewise a slight amount of fever, with vomiting and diarrhœa; while in another, there was vomiting coupled with a mild attack of jaundice.

On the admission of the patients into hospital, the only marked symptom was general anasarca of varying intensity, from slight but diffuse puffiness of the integuments up to a considerable infiltration of the sub-cutaneous cellular tissue. The skin was, as a rule, somewhat paler than usual. The remaining organs, and even those which had been affected at the outset of the disease, were in a healthy condition. The feverish symptoms had likewise disappeared. In nine of these patients, the urine presented no trace of albumen, either on their entrance into, or during their whole stay in hospital; it was perfectly natural, moreover, both as regards quantity and chemical composition. In two cases, however, the following phenomena were observed; in one man, who was admitted on the fourth day of the disease, a considerable amount of albumen was found in the urine on that and the succeeding day; on the sixth and seventh day it had gradually diminished; on the eighth, it was barely discernible; and on the ninth day it had entirely disappeared. The dropsy however was not removed until the seventeenth day. In the second case, admitted on the fifth day of the disease, a small quantity of albumen was found on the sixth and seventh day, but none whatever on the eighth.

Of these eleven cases, nine were cured and two left the hospital relieved. In none did the disease last longer than a month.

An analysis of the blood was made in each of these cases, and the mean results thus obtained will be found in the subjoined table.

Analysis of 1000 *grammes of blood.*

	Mean.	Maxima.	Minima.
Specific gravity	1045.84	1053.30	1037.55
Water	830.78	...	...
Globules	104.58	134.88	70.10
Solid matters of the serum	61.87	65.62	57.24
Fibrin	2.77	4.10	1.25

Analysis of 1000 *grammes of serum.*

	Mean.	Maxima.	Minima.
Specific gravity	1022.61	1024.28	1020.05
Water	928.47	...	...
Albumen	58.52	63.18	51.12
Extractive matters and salts	13.01	17.14	7.74

The Globules are less liable to decrease than in cachectic dropsy; they nevertheless fell, in one case to 70, and in another to 72. In three cases they were above 120 per 1000; in three others, between 100 and 120; and in five cases, between 100 and 110.

The Fibrin underwent a marked diminution in two cases only, viz., between 1 and 2 per 1000; in six cases it varied from 3 to 6, while in three others it rose above 3 per 1000.

The Albumen of the Serum was always diminished, and in some instances this diminution was considerable; it ranged from 60 to 66 in four cases, and from 55 to 60 in six others, while in one case it fell as low as 51.02.

It is almost needless to add, that the specific gravity of both the blood and serum was always found to have fallen below the standard of health.

Such then is the history of acute dropsy. We have now to interpret and explain its attendant phenomena.

And first, two prominent facts present themselves to our notice; the one being the dropsy, and the other a modification of the blood, consisting in a decrease of the albumen, and of the specific gravity of the circulating fluid itself.

What is then the correlation of these two facts? Upon which of the two does the other depend, or are they independent of each other? To answer such questions, is somewhat more difficult than might be *à priori* imagined. If, in fact, we admit that the alteration of the blood precedes the dropsy, how are we to explain the decrease of the albumen in those cases, where there has not existed (as in cachectic dropsy) any material appreciable cause, to account for the impoverishment of the vital fluid? This difficulty however is not insurmountable, and the following simple explanation may perchance prove satisfactory.

Of the eleven cases quoted above, two were admitted before the seventh day of the disease.

What then did we find in these two cases? An expiring albuminuria, if we may be permitted to use such an expression. On admission, a certain amount of albumen is found in the urine, its decrease is watched, and about the eighth day it is found to disappear entirely. In such a case, the modification of the blood admits of easy explanation.

It is evident, in fact, that the following sequence of events took place. These two individuals, whether under the influence of cold or of some other cause, were attacked with a certain amount of congestion of the kidney. This congestion was manifested by the escape of albumen along with the urine, which lasted as long as the congestion itself; viz., seven or eight days, and then ceased. Under the influence of this escape of the albumen, the proportion of that element naturally existing in the blood became diminished, the density of the serum fell, and dropsy was produced. But the change in the composition of the blood, when once effected, lasts for some time after the disappearance of the albumen from the urine, and as long as this change exists, so long will the dropsy likewise exist. Had these two patients not been seen until the eighth day of the disease, no albumen would have been found in their urine; the diminished amount of that constituent existing in the blood, together with the dropsy, could alone have been discovered, and their correlation would thus have been lost.

In these two cases, this solution of the problem would appear simple and rational, nor do we think it can well be contested. But will it hold good with respect to the remaining nine cases? We think it will; and we admit the same, by induction it is true, but yet upon certain plausible reasons, which are the following.

1. As these nine patients were not admitted into hospital until after the seventh day of the disease; we may readily conceive the albumen to have disappeared from the urine previous to admission.

2. The symptomatic expression of the disease was the same in every case. In several of them its onset was marked by a combination of phenomena, sufficiently characteristic of acute congestion of the kidney (active hyperæmia).

3. The modification of the blood was the same in each of the eleven cases.

4. The progress and duration of the disease were likewise identical in each.

We may now therefore offer the following summary of our theory; for, however rational and satisfactory, it is still but a theory.

Under the influence of some cause or other, congestion of the kidney is produced. The congestion is indicated, along with other symptomatic phenomena, by the escape of a certain amount of albumen with the urine; this, ere long, diminishes the natural proportion of the albumen of the blood, and the latter condition in its turn gives rise to a greater or less degree of dropsy. We may here observe that, when this decrease of the albumen takes place rapidly, dropsy is produced with greater facility and with less diminution on the part of this constituent of the blood, than when it occurs in a chronic form. But the congestion of the kidney is generally of much shorter duration than the modification of the blood and its consecutive dropsy; it disappears therefore long before these latter phenomena, and if the patients are not examined until a certain time after the onset of the disease, they alone are observed, the escape of albumen with the urine having altogether ceased.

If the theory which we have thus propounded be the true one, it would seem advisable to designate the disease in question, as congestion or active hyperæmia of the kidney, rather than as acute dropsy from decrease of the albumen of the blood. We do not, however, deem ourselves authorized to make such a change, being unable, as yet, to elevate our hypothesis to the rank of a positive fact, at least, in the majority of cases.

Practical Conclusions to be deduced from the Analysis of the Blood in Dropsy.

The facts which we have now passed in review, together with the distinctions which we have established, lead to important practical consequences. To determine these with accuracy, we must examine separately the two forms of dropsy previously alluded to.

A. *Cachectic dropsies.*—In the treatment of cachectic dropsy, the first indication to be fulfilled is the removal of the cause giving rise to the modification of the blood—a modification consisting, as we have seen, in a simultaneous decrease of the globules and of the albumen of the serum. Occasionally, the removal of the cause is possible. Thus, hæmorrhages, diarrhœas, etc. may often be arrested, and even cured; the effects of insufficient nourishment may disappear under the influence of improved diet: the same may be said of want, of misery, and of residence in a damp, dark locality. In other cases, the removal of the cause is somewhat difficult: thus, in marsh cachexy, the patient must be removed from the influence of the marsh miasm: or should he be no longer exposed to their noxious effects, it is still necessary to prevent the incessant recurrence of those aguish attacks which, even when the miasmatic effluvia has ceased to exercise its deleterious influence, may alone suffice to produce the marsh cachexy. In spite of this, however, the marsh cachexy frequently persists, with the greatest obstinacy, even when the patient has been removed from the poisonous action of the miasm, and has ceased to suffer from attacks of intermittent fever.

The *causes* of cachectic dropsy cannot, however, always be removed. Thus, hæmorrhage may depend upon some organic lesion or cancerous affection; a flux may depend upon chronic inflammation, etc., etc. Under such circumstances, all we can do is to check the evil consequences resulting from such conditions, and thus prevent the increase of the dropsy.

Therapeutic agents.—In the treatment of cachectic dropsy, the most useful remedies are cinchona, in various forms—the extract, the wine, etc.; the vegetable bitters, and more especially gentian. Iron is likewise indicated when the pallor of the surface is marked, or where vascular murmurs, together with the analysis of the blood, indicate that the globules and albumen have suffered a simultaneous decrease. The administration of tonics and bitters requires perseverance, as the cure of these forms of dropsy is generally very tedious and prolonged.

Stimulant frictions of every kind, dry friction, aromatic, alcoholic and ammoniacal frictions, may likewise be employed in various forms. They require however to be persevered in; we know of few measures more calculated to promote the reabsorption of the fluid effused into the sub-cutaneous cellular tissue.

The dropsy itself must be attacked in some cases; but this requires much caution. Should the amount of effused fluid be but trifling, it need not be made the object of special interference, as it will be found to diminish in proportion as the blood recovers its healthy condition, and to disappear entirely when that object has been thoroughly attained.

Should the dropsy be considerable and threaten to invade the serous cavities, measures must be adopted to hasten its removal. When this becomes necessary (and it is always an unfortunate necessity, since the appropriate remedies cannot act without weakening and exhausting the patient and still further impoverishing his blood), what are the therapeutic agents to which we must have recourse?

In the first place, we object to the use of purgatives. They weaken an already exhausted organism, and frequently produce secondary lesions of the digestive apparatus. As for diuretics, they are in general very uncertain, and require moreover the introduction of such a large amount of fluid into the system, as to be productive of even more inconvenience than the diuresis to which they might give rise. It is to the hot-air bath that we must have recourse, whenever the progress and intensity of the dropsical symptoms call for direct interference.

Hygienic measures.—These exercise a great amount of influence upon the cure or amelioration of cachectic dropsy. Thus, we cannot too strongly recommend a tonic regimen, nitrogenized food, especially meat, with a moderate quantity of generous wine; the choice of a healthy, well-ventilated country residence, warm clothing, flannel next the skin, moderate exercise, whether on foot or in a carriage; and, lastly, the removal of the patient to a milder climate. Such are the agents which hygiene affords in these cases.*

B. *Acute Dropsy.*—In this form of dropsy, a knowledge of the changes occurring in the fluids is of no less therapeutic importance than in cachectic dropsies.

The first point is to ascertain whether there be any albumen in the urine. If so,—and especially if it be accompanied by fever, general uneasiness, and gastric derangement,—the indication for bleeding is clear, and it usually succeeds, as we have noticed in several instances, where the abstraction of blood was almost immediately followed by the disappearance of the albumen from the urine, and the arrest of the dropsical symptoms. In such cases, it may sometimes be advisable to have recourse to leeches or cupping over the region of the kidneys. When the albumen has left the urine, and in those cases in which its presence there has never been detected, the use of blood-letting may be dispensed with, being reserved merely for those cases in which the dropsy is accompanied by fever.

To procure the removal of the effused fluid, various means may be adopted. Purgatives are productive of less inconvenience here than in cachectic dropsy, and may undoubtedly prove serviceable; we nevertheless prefer the hot air bath, as acting with greater rapidity, and causing less fatigue to the patient. We object to the use of diuretics for the same reasons as in cachectic dropsy. Stimulant frictions, however, may be used with advantage, and should be had recourse to in connexion with the hot air baths. We need not pay attention to the state of the globules, as they are seldom altered: iron, therefore, need not be given.

With a view of restoring the albumen to its natural standard, recourse may be had to cinchona and the vegetable bitters. These remedies, however, are of less value in acute than in chronic dropsy, owing to the fact that in the former variety the decrease of the albumen is generally less than in the latter. In the acute form, indeed, the effusion of serum occurs for the most part in connexion with a less diminution on the part of the albumen than in the chronic form. Hence it is that well-regulated hygienic measures are almost always sufficient to restore the albumen to its natural proportions.

ARTICLE X.

OF THE MODIFICATIONS OF THE BLOOD IN ORGANIC DISEASES OF THE HEART.

In order thoroughly to appreciate the changes which the blood undergoes in organic diseases of the heart, we must admit a threefold division of these diseases, which, although strictly warranted, we advocate merely as a means of facilitating investigation.

We designate the *first stage of heart disease*, as that marked merely by local phenomena, a few physical signs, and a slight amount of dyspnœa and palpitation. The constitution is as yet unaffected, and, apart from the local condition of the heart, the general health appears satisfactory.

We designate the *second stage of heart disease*, as that in which the general health has become much deteriorated. The dyspnœa and palpitation have attained a considerable degree of severity; lastly, a slight amount of œdema is apparent in the lower extremities.

We call the *third stage of heart disease,* that in which the affection has attained its full development; the countenance assumes a yellowish white, cachectic appearance; the dropsy and sense of suffocation are considerable, and the individual is doomed to a speedy death.

SECT. I.—Diseases of the Heart. First Stage.

In this stage, the cardiac disease is indicated by certain physical signs and local phenomena. The constitution remains unaltered. We may remark, however, that, in certain cases of chronic endocarditis, there may be in addition a certain degree of anæmia, as evinced by slight pallor of the surface and by vascular murmurs.

In this stage of cardiac disease, does the blood undergo any change?

Having analysed the blood of fifteen persons (eleven males and four females) labouring under the first stage of organic disease of the heart, we are in a position to answer this question. We shall first bring forward the general results thus obtained, and then arrange the same in a tabular form.

In the early stage of organic heart disease, the proportion of water in 1000 parts of blood increases, and the specific gravity of this latter fluid consequently diminishes; the globules decrease somewhat, their mean being represented by 125; the fibrin remains unchanged; lastly, the albumen contained in 1000 parts of serum undergoes a trifling diminution, proportionate to that of the globules, its mean being represented by the figures 71.05. As a consequence of the mean decrease of these two constituents of the blood, we find a corresponding decrease of the mean density, both of the blood and of the serum.

Such are the general results of our analyses. But on examining them separately, we at once feel ourselves called on to make certain distinctions. Some individuals, for instance, are affected with simple hypertrophy, unaccompanied by valvular disease; in others, on the contrary, the valvular lesion predominates, while the hypertrophy is but a consequence of such lesion. In these two groups, the characteristics of the blood are essentially different.

In the first, viz., simple hypertrophy, the proportion of the globules is considerable, attaining, indeed, the utmost physiological limits; the same may be said of the albumen and fibrin. The specific gravity of both the blood and serum constitutes an expression of the fact.

In the second group, chronic endocarditis or valvular disorganization is the prominent lesion. In such cases there frequently exists, more especially in females, a slight degree of anæmia, and the representative number of the globules is found to be less than usual. This condition of the blood, however, differs from ordinary anæmia, in being almost invariably attended with a trifling decrease of both the albumen and fibrin. Such are the general results, given in a crude form. We pass on now to some statistical details.

Of the fifteen cases, as previously stated, eleven were males and four were females. As regards age, ten were below forty, three between forty and fifty, one between fifty and sixty, and one upwards of sixty years of age. With reference to the nature of the disease we may state, that there were six cases of simple hypertrophy, four cases of auriculo-ventricular contraction with slight hypertrophy, three cases of auriculo-ventricular insufficiency with a similar condition of the heart's walls, and, lastly, three cases of aortic contraction.

Table shewing the mean composition of the blood, with the maxima and minima.

Analysis of 1000 *grammes of blood.*

	Mean.	Maxima.	Minima.
Specific gravity of the blood	1056.26	1065.34	1049.85
Water	795.96	...	...
Globules	125.22	166.00	78.90
Solid matters of the serum .	76.34	102.00	58.76
Fibrin	2.48	7.51	1.54

Analysis of 1000 *grammes of serum.*

Specific gravity of the serum	1026.98	1037.20	1022.16
Water	912.76	...	...
Albumen	71.55	101.10	53.10
Extractive matters and salts	15.69	17.70	15.77

On extending our inquiries somewhat further, we obtain the following results:

The Globules.—In eight cases they rose above 130; in three others they oscillated between 120 and 130; in one between 100 and 110; and in three they fell below 100. It is more especially in cases of simple hypertrophy occurring in robust individuals that the globules are found to exceed 130 parts per 1000.

The Fibrin.—In three cases it rose above 3 per 1000; in four others it varied from 2.05 to 3; in five others from 2 to 2.05; lastly, in 3 cases it fell below 2. The last eight were cases of chronic endocarditis.

The Albumen.—It oscillated between 90 and 100 in one case; between 80 and 90 in another; between 70 and 80 in seven cases; between 60 and 70 in five cases; and in one case it fell below 60. The latter were likewise cases of chronic endocarditis.

SECT. II.—Diseases of the Heart. Second Stage.

The physical signs are now more clearly defined, and the local symptoms more marked; the general health begins to fail, and the constitution to evince signs of deterioration; a slight anæmic appearance is noticed in many persons; together with a tendency to œdema of the lower extremities.

The following are the general results afforded by an analysis of the blood in twenty-four of these cases. The proportion of water in 1000 parts of blood is still greater than in the preceding category, the specific gravity of the blood is likewise lower; the globules undergo a still further diminution, their mean being represented by 117. The fibrin, far from decreasing, augments in many cases, and for no obvious reason. Without any trace of inflammatory action, we have found it as high as 6.46. Lastly, the albumen decreases like the globules, its mean proportion in 1000 parts of serum being 66.21. The mean density of both the blood and serum is less than in the first stage of organic heart disease.

Two circumstances more especially influence the composition of the blood in the second stage of organic heart disease, viz., the anæmia and the dropsy. The former is indicated by a decrease in the proportion of the globules, and the latter, at its onset, by a similar decrease on the part of the albumen. The following table affords a statistical analysis of these cases:

Table shewing the mean composition of the blood in twenty-four cases of the second stage of organic heart disease.

Analysis of 1000 *grammes of blood.*

	Mean.	Maxima.	Minima.
Specific gravity of the blood	1052.54	1066.80	1040.88
Water	801.96	...	...
Globules	117.05	149.42	54.00
Solid matters of the serum .	77.53	99.50	61.74
Fibrin	3.46	6.46	1.25

Analysis of 1000 *grammes of serum.*

Density of the serum . .	1027.60	1035.10	1020.16
Water	921.31	...	...
Albumen	66.21	103.50	53.28
Extractive and fatty matters, and salts	12.48	20.85	6.00

Of these twenty-four cases, eighteen were males and six females. Two were under twenty years of age, two between twenty and thirty, six between thirty and forty, six between forty and fifty, five between fifty and sixty, and four were upwards of sixty years of age.

Sixteen were endowed with a robust, and eight with a feeble constitution.

There were two cases of simple hypertrophy; sixteen of auriculo-ventricular contraction with hypertrophy; one of aortic contraction with hypertrophy; two of auriculo-ventricular insufficiency with hypertrophy; and, lastly, three of aortic patency with hypertrophy.

Anæmia was present in ten of these cases, and a slight amount of dropsy in eleven.

We subjoin the following details relative to the chief constituents of the blood.

The Globules.—In eight cases they exceeded 130 per 1000; they varied from 120 to 130 in four cases; from 110 to 120 in seven cases; from 100 to 110 in one case; and in five cases they fell below 100.

In almost all the anæmic cases, the globules fell below 120 per 1000.

The Fibrin.—In nine cases it exceeded 3.5 per 1000 (a large proportion, for which we were unable to account); in ten cases it oscillated between 2.5 and 3.5; in three cases between 2 and 2.5; and in two cases it fell below 2.00.

The Albumen.—In one case it rose to upwards of 90 per 1000; in six cases it oscillated between 80 and 90; in eight between 70 and 80; in five between 60 and 70; while in three it fell below 60.

We may remark, that in general the proportion of albumen was normal, even in cases where dropsy had already commenced; but, on the other hand, the only cases in which it was found to have somewhat diminished, were those in which slight dropsical symptoms had already manifested themselves.

SECT. III.—Diseases of the Heart. Third Stage.

In this class we comprehend all those cases in which the disease has reached an advanced stage. The dyspnœa and palpitation are now very severe; the serous infiltration is considerable, and often invades the pleural and peritoneal cavities as well as the sub-cutaneous cellular tissue; at the same time, the constitution affords marked evidence of deterioration; the cutaneous surface, especially of the face, is pale, and presents that characteristic tinge specially attributed to the cachectic condition which accompanies organic diseases of the heart; lastly, the combination of symptoms in such cases announces the speedy approach of death.

Under these circumstances the blood, for the most part, undergoes great modifications, of which the following is a general outline.

The amount of water in 1000 parts of blood is greatly increased, while the solid matters are proportionately diminished. The specific gravity of the blood is also greatly reduced. The globules undergo a very considerable decrease: their mean being represented by the figures 110.

The fibrin falls to its lowest physiological limits, varying for the most part between 2. and 2.5 per 1000. It sometimes, indeed, falls still lower, in which case there is usually a general hæmorrhagic tendency. We have noticed this in two cases. But the most remarkable change is that which takes place in the serum. Its specific gravity is almost always lowered; the proportion of water is larger than usual, and the albumen, extractives, fatty matters, and salts are diminished. In other words, the serum undergoes a similar modification, although less marked, to that which occurs in the chronic form of Bright's disease. It is worthy of notice, that this modification of the serum is greater in proportion to the extent and intensity of the dropsical phenomena, and to the proximity of the fatal termination.

What, then, we may ask, is the cause of this decrease on the part of the albumen and extractives of the blood? We shall endeavour to answer the question by appealing to the results of our analyses, premising, however, that having but a theory to offer, we do so with the utmost reserve.

We first remark that the said decrease is consecutive to the dropsy. It only takes place upon the latter becoming well marked. Probably, therefore, it is due to the impoverishment which the blood undergoes by reason of the loss of serum constituting the dropsy. When once the blood has become impoverished by the occurrence of mechanical dropsy, it is probable that the infiltration proceeds with increased rapidity, and that the serum, now more watery than heretofore, escapes with greater facility under the influence of two causes acting in the same direction, viz., the impediment to the circulation, and the diminution of the solid matters of the serum.

Table shewing the mean composition of the blood in thirty-one cases of diseases of the heart, in the third stage.

Analysis of 1000 *parts of blood.*

	Mean.	Maxima.	Minima.
Specific gravity of the blood	1050.19	...	...
Water	815.82	...	...
Globules	110.03	148.55	73.59
Solid matters of the serum .	71.60	81.10	52.40
Fibrin	2.55	4.47	1.30

Analysis of 1000 *parts of serum.*

	Mean.	Maxima.	Minima.
Specific gravity of the serum	1025.02	1032.50	1022.30
Water	920.76	...	...
Albumen	64.72	76.13	53.21
Extractive and fatty matters, and salts	14.52	26.32	10.02

The following is a statistical summary of the thirty-one cases which furnished the substance of the above tables.

Of these thirty-one cases, nineteen occurred in males and twelve in females. Five were between twenty and forty years of age, seven between forty and fifty, twelve between fifty and sixty, and seven were upwards of sixty years of age.

Of these cases, there were twenty of left auriculo-ventricular contraction with hypertrophy, four of auriculo-ventricular insufficiency, two of aortic contraction, and five of aortic patency. In the last eleven cases there was likewise a greater or less degree of hypertrophy.

In order to explain the composition of the blood in these cases, it is necessary to take into account the complications which existed. Of these thirty-one patients, twenty-nine were affected with dropsy in various degrees, twenty-seven presented indications of that cachectic condition which is generally supposed to accompany organic disease of the heart, viz., a pale yellowish cast of countenance, with general decolorization of the skin. These two latter complications were found to exist in almost every case.

The remaining complications were more rare. Thus, there were five cases of pulmonary emphysema and two of subcutaneous hæmorrhage. In these last the proportion of fibrin had fallen as low as 1.43 and 1.30 per 1000. Lastly, in one case with pleuritic complication the fibrin rose to 4.47.

The modifications occurring in the chief constituents of the blood were as follows:

The Globules.—In nine cases they were found to be above 130 per 1000; in nine others they varied from 120 to 130; in five from 100 to 120; in two from 90 to 100; in three from 80 to 90; and in three they fell below 80. The decrease of the globules was most marked in those cases in which the disease had reached its most advanced stage, and where the peculiar cachectic tinge of the surface was very distinct. In general, however, the decrease, as we have just seen, was not very considerable.

The Fibrin.—This constituent of the blood undergoes great diminution in many diseases of the heart, and this diminution is most marked in proportion as the disease advances. Of the thirty-one cases quoted above, the fibrin in four, rose above 3.5 per 1000; in nine it varied from 2.5 to 3.5; in six from 2.0 to 2.5; and, lastly, in twelve cases it fell below 2. We would especially call attention to these last twelve cases, in which, nevertheless, there were but two which presented any hæmorrhagic complication.

The Albumen.—The proportion of albumen contained in 1000 grammes of serum varied considerably. In ten cases it afforded from 70 to 80 parts per 1000; in fourteen, from 60 to 70; in seven, from fifty to sixty. Thus of thirty-one cases, twenty-one were below the mean. We must observe, moreover, that in the last seven cases the cachectic condition of the system was most clearly marked, and the amount of dropsy very considerable. In one of these thirty-one cases, venesection was performed thrice, and its effects upon the chief constituents of the blood were as follows.

The specific gravity, which was at first 1056.10, fell to 1054.61, and then to 1053.10.

The globules fell from 138.68 to 125.81, and subsequently to 120.73.

The fibrin fell from 3.0 to 2.37, and in the third bleeding to 1.12.

The specific gravity of the serum did not vary much: at the first bleeding it was 1025.37, at the second 1025.60, and at the third 1025.01.

The albumen underwent but little change: it fell from 70 to 69.84, and then to 66.60.

In another case, venesection was twice performed, with similar results.

Practical Conclusions deducible from an investigation of the Changes which the Blood undergoes in Organic Diseases of the Heart.

It is evident, that from the above details certain principles may be deduced, which we conceive to be worthy of serious consideration in the treatment of cardiac disease.

In simple hypertrophy of the heart, the orifices being free and the valves healthy, the blood is rich in solid matters, its specific gravity is high, and its watery portion is less than usual. The globules are abundant, and the proportion of albumen and fibrin somewhat high. Hence the beneficial effect of blood-letting in these cases; the fact itself has long been known, but it derives an additional sanction from a study of the alterations of the blood.

In diseases of the valves and orifices complicated with hypertrophy, the blood undergoes a change in the opposite direction. In proportion as the disease progresses, as the local symptoms become aggravated, and more especially as the œdematous infiltration increases, the solid constituents of the blood diminish in quantity, and its specific gravity falls. The decrease of the fibrin and albumen is considerable: that of the globules being somewhat less so.

What, then, we may ask, is the cause of so great a change in the composition of the blood? Is it to be attributed to the mechanical impediment offered to its free circulation? or, what appears to us more probable, must it be sought for in the impoverishment produced by the escape of the fluid constituting the dropsy, and by the energetic measures usually taken to combat this terrible accident? Whatever be the answer, it is not the less certain that this modification of the blood deserves our utmost consideration, and should dictate certain therapeutic rules. In the first place, the decrease of the globules indicates the propriety of administering the preparations of iron. Indeed, it has long been known that the ferruginous salts are productive of the best effects in many cases of organic heart disease: they must not, however, be given indiscriminately.

The decrease of the albumen suggests the employment of cinchona. The cachectic tinge of the skin and the dropsy, constituting the standard, as it were, by which this decrease may be measured, it is by them that we must be guided in the administration of this therapeutic agent.

As regards the decrease of the fibrin, it more especially indicates the necessity for a frequent use of animal food of easy digestibility. We know, in fact, that many practitioners prescribe such a regimen in this class of diseases. A knowledge of the changes taking place in the blood adds fresh force to such a recommendation, and enables us to insist still further upon the adoption of these measures.

ARTICLE XI.

OF THE BLOOD IN DISEASES OF THE SPINAL CORD.

Diseases of the spinal cord, giving rise to paraplegia at a certain stage of their existence, generally run a chronic course, and rarely occur in hospitals under circumstances which necessitate the employment of general bleeding.

For this reason we have deemed it expedient to seize every opportunity which might present itself of making as complete an analysis of the blood as possible, both in diseases of the cord and in the complications which occur in such cases.

We have thus been enabled to collect the results afforded by twelve analyses of the blood drawn from nine males, all of whom were bled once, and three twice.

Our materials, however, not being sufficiently abundant to generalize upon the results thus obtained, we shall content ourselves with as succinct a summary as possible.

1. Two females, the one aged eighteen, the other forty-two years, were bled during the progress of a disease of the vertebræ, which had produced deformity, and almost complete paralysis.

These two patients were bedridden, their constitution had undergone a marked deterioration, and they were much emaciated. In both, the blood contained less solid matters than in health, and presented all the characteristics of the anæmic condition.

Analysis of 1000 *grammes of blood.*

	A female, 18 years of age.	A female, 42 years of age, bled on account of a bronchitic complication.
Water	819.2	833.2
Globules	94.0	78.0
Solid matters of the serum	84.1	83.0
Fibrin	2.7	5.0

Analysis of 1000 *grammes of serum.*

Water	906.9	908.6
Solid matters	93.1	91.4

2. A man, fifty-six years of age, died of paraplegia symptomatic of a disease of the cord, which developed itself with great rapidity. The affection ran through its entire course in from thirty to forty days, reached the superior extremities, and at last caused death by paralysis of the muscles of respiration. This man was bled five days previous to his decease, and the analysis of the blood drawn was as follows:

Analysis of 1000 *grammes of blood.*

Water	783.5
Globules	124.0
Solid matters of the serum	89.1
Fibrin	3.4

Analysis of 1000 *grammes of serum.*

Water	897.9
Solid matters of the serum	102.1

At the autopsy we merely discovered a congested state of the spinal marrow, without a trace of ramollissement or of organic lesion.

3. Five other individuals suffering from disease of the cord, and presenting the symptoms usually observed in such cases, were bled, and in two the bleeding was repeated. Of these five, the two first, one aged twenty-six, the other forty-five years, were affected with complete paraplegia, which rendered them unable to leave their bed: they were both bled on admission. The third case was that of a woman forty years of age, who presented symptoms of myelitis and chronic ramollissement of the cord. The remaining four analyses were made of the blood drawn from a man aged thirty-three, and a woman aged forty-six years; both were affected with paraplegia, dependent on chronic myelitis. The majority of these patients were completely bed-ridden, and their constitution appeared much debilitated.

We subjoin a table, shewing the analysis of the blood in these seven cases:

Analysis of 1000 *grammes of blood.*

	A male, age 40.	A male, age 45.	A female, age 40.	A male, aged 33.		A female, age 46.	
				1st VS.	2nd VS.	1st. VS.	2nd VS.
Water . .	826.5	804.4	799.5	789.3	903.6	916.4	952.8
Globules . .	78.2	89.2	111.0	129.3	108.6	110.6	75.6
Solid matters of the serum	90.3	104.4	85.7	85.4	70.0	70.3	69.0
Fibrin . .	5.0	5.0	3.8	2.4	3.0	3.0	2.6

Analyses of 1000 *grammes of serum.*

	A male, age 40.	A male, age 45.	A female, age 40.	A male, aged 33.		A female, age 46.	
				1st VS.	2nd VS.	1st. VS.	2nd VS.
Water . .	901.5	888.0	904.5	907.9	904.0	921.5	925.1
Albumen . .	89.4	87.3	95.5	80.9	86.7	68.9	68.8
Extractive and fatty matters, and salts .	11.1	24.5		11.2	9.3	9.6	9.1
Sp. gr. of serum	1030.6	1033.8	1030.0	1026.7	1028.9	1025.0	1023.1

4. In the ninth and last case, that of a man thirty-six years of

age, and of robust constitution, bled twice on alternate days, on account of two violent attacks of intermittent tetanus of the extremities, attended with acute pain; we obtained the following results:

Analyses of 1000 *grammes of blood.*

	1st Bleeding.	2nd Bleeding.
Water	797.3	824.2
Globules	114.3	93.1
Solid matters of the serum . .	84.3	78.6
Fibrin	4.1	4.1

Analysis of 1000 *grammes of serum.*

Water	904.4	913.8
Albumen	85.8	76.6
Extractive and fatty matters .	9.8	9.6
Specific gravity of the serum .	1039.0	1025.7

Such were the results afforded by the analysis of twelve specimens of blood, drawn from nine persons suffering from disease of the spinal cord. They may be summed up as follows:

When disease of the cord is attended with paraplegia, we generally find a marked decrease of the globules, proportionate to the advanced stage of the disease and to the debility of the patient. In some of our cases, the proportion of globules was even less than in chlorosis, and yet no bellows murmur was audible in the carotids. At the second bleeding, the decrease of the globules became still more marked, the appetite of the patients, however, remained for the most part unimpaired, so that this condition of the blood must be attributed to the influence of the disease itself, and not to a restricted diet.

The proportion of fibrin was sometimes natural; at other times, owing to intercurrent attacks of inflammation, it rose as high as 5.4.

The specific gravity of the serum was generally high: it almost always contained a large proportion of solid matters, alike rich in albumen, extractive and fatty matters.

Before passing on to an examination of the blood and serum in other diseases, we must allude to certain exceptional cases of cerebral affection, in which an analysis of these fluids was made.

1. In a female, long the subject of incomplete hemiplegia, two bleedings were practised at short intervals, with the view of warding off an anticipated recurrence of apoplectic symptoms: 1000 parts of serum afforded in the first bleeding 88.2; in the second, 85.5 parts of albumen; and in each, a large proportion of extractive and fatty matters, etc., 12.7 and 10.5.

2. A man under somewhat similar circumstances, affected with hemiplegia of several months duration, and in whom a renewal of the attack was feared, being bled, 1000 parts of serum were found to afford 909 of water and 91 of solid matters.

3. A young female, twenty-eight years of age, presented all the symptoms of circumscribed encephalitis, characterized by complete paralysis of motion and sensation of the left side of the face, of the upper part of the trunk and of the left arm, but with only slight paralysis of motion of the left leg; there was, moreover, high fever. Bleeding was practised on four occasions, after each of which the serum became more and more impoverished, as is shewn by the following table:

Analysis of 1000 *grammes of blood.*

	1st Bleeding.	2nd Bleeding.	3rd Bleeding.	4th Bleeding.
Specific gravity .	1029.0	1028.4	1025.3	1024.2
Analysis of 1000 *grammes of serum.*				
Water . . .	903.6	911.4	915.3	919.4
Solid matters .	96.4	88.6	84.7	80.6

ARTICLE XII.

OF THE COMPOSITION OF THE BLOOD IN TUBERCULAR DISEASE OF THE LUNGS.

The modifications which the blood undergoes in tubercular disease of the lungs, have long been a subject upon which physicians have exercised their imaginative powers, and many are the hypotheses that have been brought forward to account for the primary cause giving rise to the development of this accidental product in the organism. It is not, however, until we arrive at the researches of MM. Andral and Gavarret, that we find the analysis of the blood affording positive information on the subject. Without pretending to discover the primary cause of tubercle, or to assign any special reason for its development, these experimenters have established the fact, that in pulmonary phthisis the blood undergoes a twofold change.

The first consists of a decrease in the proportion of the globules; this decrease, which occurs at the commencement of the disease, continues up to the fatal termination. "Thus," says professor Andral (*Traité d'Hématologie,* p. 171), "the "condition of the blood which coincides with the earliest "stage of tubercular phthisis, and which, in all probability, "precedes the actual manifestation of the disease, is analogous "to that general condition of the blood which we meet with "in all cases, where, from some cause or other, the vital powers "have lost their energy." The next change noticed by these authors is an increase of the fibrin, occurring, however, only when the parts adjacent to the tubercular deposit take an inflammatory action.

Of these two modifications of the blood, the first precedes the development of the tubercle, and is its constant concomitant. The second, on the contrary, is but a consequence of the deposition, and is due to an inflammatory complication occurring in the tissues which surround the morbid product.

Not long since, M. Felix Boudet having stated, in a communication read before the Academy of Medicine, that he had found a large amount of fatty matter, and especially of cholesterine, in the tubercles, as well as in the liver of phthisical patients, when this organ was the seat of fatty degeneration; propounded a theory which appeared to recommend itself to the judgment of those members who were commissioned to report upon the communication in question. According to these views, the blood of phthisical individuals contains an excess of fatty matters.

We have ourselves analyzed the blood in thirty-two cases of phthisis. In sixteen of these a complete analysis was made; in the remainder, the albumen of the serum was alone made the object of investigation by means of the polarimeter.

Analysis of 1000 *grammes of blood in sixteen cases of phthisis.*

	1st Bleeding.	2nd Bleeding.	3rd Bleeding.
Specific gravity of the blood	1056.7	1055.5	1050.5
Globules	125.0	122.7	103.5
Fibrin	4.8	4.2	3.6
Cholesterine	0.134	0.171	0.100
Animal soap	1.400	1.271	0.950

(In this table no reference is made either to the water or to the albumen.)

Analysis of 1000 *grammes of serum in sixteen cases of phthisis.*

Specific gravity of the serum	1028.0	1026.3	1025.50
Pure albumen	76.20	75.0	72.10

We may thus sum up the characteristics of the blood in tubercular disease of the lungs.

At the very commencement of phthisis, when uncomplicated, the composition of the blood presents nothing unusual; as the disease progresses, however, and the softening of the tubercular matter becomes attended with certain inflammatory complications, such as pneumonia, bronchitis, and pleurisy, the blood undergoes changes, very similar to those which occur in the phlegmasiæ. The decrease of the globules, however, is more rapid and marked.

Under the influence of hæmoptysis, or of protracted diarrhœa, the globules continue to decrease, and often fall to a very low figure.

When phthisical patients are bled, the blood is found to be remarkably deficient in globules; it is difficult, however, to say whether this decrease is to be attributed to the bleeding, or to the progress of the disease.

In this disease, the saponified fatty matters of the blood decrease, perhaps, more than in any other; whether as the result of the disease, or of the previous bleedings. We are far, therefore, from finding an excess of fatty matter in this fluid.

In the majority of somewhat advanced cases of phthisis, there exists a true anæmic condition, *i.e.* a diminution of the total mass of blood contained in the vascular system.

Lastly, the proportion of albumen in the blood undergoes a marked decrease, even at an early stage of the disease. This is the more remarkable, as it may be attributed, not indeed to a restricted regimen, as in acute disease, for to this phthisical patients are not subjected, but to the tubercular affection itself.

The composition of the blood in phthisis, shews with what facility the deterioration of this fluid may take place, whether spontaneously or under the influence of blood-letting. This latter measure must, therefore, be used with great caution in those cases where inflammatory action is not well marked.

ARTICLE XIII.

OF THE BLOOD IN JAUNDICE.

Jaundice, considered simply with reference to the composition of the blood, may present itself under two very different conditions, which it is of great importance to distinguish. In a certain number of cases, there is an overflow of bile, consequent upon increased secretion, and this occurs simultaneously with the jaundice. In others, on the contrary, there is a retention of bile, due to some obstacle situated in the course of the biliary ducts, such as calculi, etc., or to some peculiar condition, perhaps spasmodic, which affords no indication of morbid change after death, and which constitutes what is termed simple jaundice. In this last class, the pale colour of the fæces indicates suppression, or at least considerable diminution, of the biliary secretion.

In the first class of cases, viz., those in which a bilious flux co-exists with jaundice, the fatty matters of the blood, and more especially those which are found in the bile, undergo no modification. This we have had an opportunity of ascertaining on two occasions.

In the second category, viz., where there is either a diminution or a suppression of the biliary secretion with clay-coloured fæces, the more important constituents of the bile, previously existing in the blood, are not eliminated by the liver, but becoming concentrated in that fluid, are there found in large quantity.

1. There is thus, *jaundice*, with *hypersecretion of bile*, and an escape of that fluid by the intestines. We possess notes of two such cases.

The first relates to a man suffering from congestion of the liver and possibly from hepatitis in its early stage, complicated with slight enteritis and bilious diarrhœa; there was fever, moreover, and very marked jaundice. The blood presented all those characters which we have spoken of under the head of the phlegmasiæ. The fatty matters, however, were rather less abundant than usual: their proportion being represented by 1.406; the seroline was scanty, 0.005; the cholesterine had rather increased, as is generally the case in acute diseases, especially in the phlegmasiæ, 0.234; the proportion of saponified matters was natural.

The second case is very similar to the last, with the exception of there being no inflammatory complication. It is that of a lad, aged nineteen years, labouring for some time under bilious diarrhœa, with feverish symptoms and well marked but recently developed jaundice. An analysis of the blood of this patient shewed a slight decrease of the globules (136); a healthy proportion of albumen (71.4) and fibrin (2.3); a fair amount of fatty matters; a very small quantity of seroline; a great abundance of cholesterine (0.798); animal soap (2.032). To what cause are we to attribute the large proportion of cholesterine? How and wherefore did it accumulate in the blood in spite of the bilious diarrhœa? The question does not admit of a ready answer.

2. There is *jaundice*, with diminution or suppression of the biliary secretion, and pale clay-coloured evacuations. This is termed simple jaundice, and here we have not merely an accumulation of cholesterine in the blood, but of the other fatty

matters likewise. We have proofs of this afforded by an analysis of that fluid in several cases of simple jaundice. These we have comprised in two separate series, the first containing two cases, in which the fatty matters of the blood were most carefully investigated. The second containing eight cases, in which an examination of the fatty matters was dispensed with in favour of the albumen, fibrin, and globules.

First Series.—The first case is that of a young man, twenty-three years of age, affected with simple non-febrile* jaundice, which had commenced three days before admission, as the result of an attack of indigestion. There was constipation, with clay-coloured fæces. An analysis of the blood gave the following results: water 740.509; globules very abundant (164.3: this was the highest number we have ever met with in our analyses).—We may remark, that the patient presented no indication of plethora, nor was there any derangement of the nervous system.—The fibrin was somewhat diminished (1.9); the albumen likewise (66.3); the fatty matters were very abundant (3.646), being more than doubled. Thus: the seroline gave 0.070; the cholesterine, 0.897; and the animal soap, 2.679. We know that the fatty acids of which the latter is composed, are likewise found in the bile in combination with soda. The salts presented nothing unusual.

The second case is that of a young man, twenty-four years of age, a baker by trade, and of tolerably strong constitution. He was attacked by jaundice, without heat of skin and with a slow pulse (56); as in the former instance, the disease set in after a fit of indigestion. There was no complication. An analysis of the blood gave the following results: the proportion of water was natural; the globules abundant, but within the limits of health (145); the fibrin likewise (2.35); the albumen had fallen to 60; the fatty matters were still more abundant than in the preceding case (4.176), and were thus distributed: seroline very abundant (0.128); cholesterine, likewise (0.942); animal soap (3.105); the salts presented nothing worthy of notice.

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* The pulse was only 60.

From the analyses of these cases we may draw the following conclusions:

In simple or complicated jaundice, accompanied by biliary flux, the fatty matters are either found unaltered, or concentrated in the blood, as in the second series of cases; there is, however, no increase of the saponified fatty acids.

In simple or complicated jaundice, with diminution or suppression of the biliary secretion (retention), there is concentration of the fatty matters, more especially of the cholesterine and saponified fatty acids, all of which are essential constituents of the bile. We may add, that the serum presents a strong tinge of bile, equally indicative of the presence of the biliary colouring matter in that fluid, or rather of its concentration there: for we believe that this colouring matter is of a similar nature to, if it be not identical with, that of the serum of the blood.

Second Series.—Analyses of eight cases of simple jaundice.

Analysis of 1000 *grammes of blood.*

	Mean.	Maxima.	Minima.
Specific gravity of the blood	1056.82	1061.05	1052.00
Water	774.90	...	...
Globules	139.38	154.21	117.51
Solid matters of the serum .	81.21	88.65	74.63
Fibrin	4.45	7.00	2.42

Analysis of 1000 *grammes of serum.*

Specific gravity of the serum	1026.70	1030.05	1023.86
Water	906.46	...	...
Albumen	76.83	86.25	70.15
Extractive matters and salts	16.71	23.11	11.12

A detailed analysis of each case affords the following results:

The Globules.—In two cases the proportion of globules was above 150 per 1000; in three others it varied from 140 to 150; and in the last three cases from 120 to 140.

It follows, therefore, that in simple jaundice, the globules either remain within the limits of health or tend to increase, since in five cases out of eight they exceeded the physiological standard.

The Fibrin.—In three cases it oscillated between 5 and 7; in three between 3.5; and in two between 2 and 3.

We have here a similar change to that which takes place in the case of the globules, viz., that, in the majority of cases of jaundice without inflammatory complication, the fibrin invariably tends to increase, and to exceed its physiological limits.

The Albumen of the Serum.—In two cases its proportions were above 80 parts per 1000; in three cases it varied from 75 to 80; and in three others from 70 to 75; in other words, the quantity of albumen did not exceed the standard of health.

We may thus sum up the modifications of the blood in simple jaundice:

a. Specific gravity of the blood, high;

b. Specific gravity of the serum, normal;

c. The proportion of globules either normal or much increased;

d. The same with regard to the fibrin;

e. Lastly, a healthy proportion of albumen;

We are unable to draw any distinct practical inferences from these results. Were it not, however, that in the great majority of cases, jaundice disappears spontaneously, we should feel inclined to recommend venesection as a means of reducing the proportion of albumen and fibrin.

ARTICLE XIV.

OF THE BLOOD IN EMPHYSEMA OF THE LUNGS.

It might not be uninteresting to ascertain the composition of the blood in idiopathic emphysema without bronchitic complication, since the habitual impediment to the circulation which exists in these cases, must of necessity exercise a certain influence upon the composition of that fluid. We have not, however, made an analysis of the blood in this disease, nor are we aware of its having ever been made; our own researches in this direction have merely had reference to the amount of pure albumen contained in the serum of twenty-five emphysematous individuals in whom venesection had been practised. Thus:

Amount of albumen contained in 1000 *parts of serum, as ascertained by the albuminimeter.*

Mean.	Maxima.	Minima.
74.34	92.52	53.82

We here notice a decrease of the albumen, occurring irrespective of a restricted regimen. The alterations of the blood in emphysema are, however, as yet unknown, and the results obtained by means of the albuminimeter afford no pathological data.

ARTICLE XV.

OF THE BLOOD IN LEUCOCYTHEMIA.

This disease consists of an increase in the proportion of the white globules of the blood. It appears to be connected with an hypertrophied condition of the spleen, and is attended with a considerable degree of marasmus.

Virchow (of Wurtzburg) was the first to establish clearly the existence of this modification of the blood, in a memoir published in 1845. His views, however, were more fully developed in two subsequent memoirs, published in 1846 and 1847.*

In the same year, Fuller, at St. George's Hospital, London, likewise noticed a disease characterized by the presence in the blood, of a large number of white globules, similar to the white globules of the blood, and which were associated with an hypertrophy of the spleen.

Drs. Walshe and Parkes of London, and Dr. Bennett of Edinburgh, have confirmed these observations.

According to this last observer, the lesions which correspond to an increase of the white globules, as ascertained by the microscope, are: *a.* hypertrophy of the spleen, which is always present; *b.* an occasional abnormal development of the liver, and *c.* a morbid enlargement of the lymphatic ganglia.

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* The priority of discovery appears due to Professor Bennett of Edinburgh. *(Trans.)*

As regards the etiology of the disease, we may remark, that the above-mentioned authors all notice the absence of intermittent fever,—a singular fact, when taken in connexion with the invariable enlargement of the spleen.

According to M. Leudet, who has written an excellent article on this subject in the *Gazette Médicale,* 1853, p. 365, the symptoms of this disease may be divided into three groups: 1. Those which usher in the malady; 2. Those which characterize its ascensive period; and 3. Those of the fully formed disease. The first of these are local; the development of the glandular organ takes place *per se,* without sympathetic disturbance of other organs; to this succeed certain cachectic phenomena, marked by the occurrence of general debility, and subsequently by chlorotic symptoms, with vascular murmurs, hæmorrhage from the mucous membranes, and more or less dyspnœa. The fatal termination is generally the result of some intestinal complication.

M. Leudet conceives it almost always possible to diagnose the disease during lifetime. Vogel, in the case which he has published, appears to have recognized this condition of the blood by microscopical and chemical investigation, previous to the death of the patient.

M. Leudet has appended to the history of the disease in question, a very singular case of leucocythemia, to which we refer the reader (*loc. cit.*).

In the case mentioned by Vogel, numerous white globules were found in the blood.

The proportion of water was greater than usual: 815.8.

That of the globules was less, viz., 97.4.

The fibrin was more abundant than in health: 4.46.

The solid matters of the serum had undergone a trifling increase: 82.3.

M. Barthe has lately observed a case of leucocythemia at the Beaujon hospital. The symptoms were those of well marked cachexia, with epistaxis recurring at frequent intervals up to the fatal termination.

In his work on leucocythemia, Dr. Bennett endeavours to establish:

1. The connexion between the red and white globules;
2. The seat of origin of the white globules;
3. Their use.

The following are the conclusions at which he arrives:

"1. The white corpuscles of the blood in the vertebrate "animals are formed in the glandular lymphatic system. In "the current of the circulation, the majority of these globules "acquire a red colour by some process as yet unknown.

"2. In the mammiferæ, the glandular lymphatic system "comprises: the spleen, the thymus gland, the thyroid gland, "the supra-renal capsules, the pituitary and pineal glands, "and the lymphatic ganglia.

"3. In fish, reptiles, and birds, the red globules are nucleated cells developed in these glands. In the mammiferæ, "they are free nuclei, originally formed in these same glands, "and sometimes developed in colourless cellules.

"4. In certain hypertrophic conditions of the lymphatic "glands, their cellular elements increase to a considerable "extent, enter the circulation, and thus constitute an increase "of the colourless globules, termed leucocythemia."

We content ourselves with a mere statement of the theory, not having witnessed any examples of the disease in question.

MM. Charcot and Robin have also published a case of leucocythemia (noticed by them at the Charité Hospital, Paris), in the *Gazette Médicale*, 1853, p. 430. It resembles, in a great measure, those previously observed.

A man, forty-five years of age, a house-painter by trade, well formed and of a good constitution, was admitted into the hospital on the 18th of April, 1853.

His previous health had generally been good. On two occasions he had been affected with venereal symptoms, but never with intermittent fever or saturnine poisoning.

During the year preceding his admission, he experienced severe afflictions, which affected his intellect.

His appetite was bad, and his stomach irritable; there was much emaciation, with considerable irritability of the nervous system.

On admission, the symptoms observed were as follows: yellow tinge of the integuments, intermittent bellows murmur in the vessels of the neck, emaciation, and great irritability.

The pulse was regular, and there were no feverish symptoms.

The respiration was natural.

Appetite tolerable, but digestion bad; no vomiting or diarrhœa.

An examination of the abdomen shewed the liver to be natural in point of size, and the spleen to be the seat of a considerable enlargement.

On the 19th, 20th, and 21st of April, the patient ate with tolerable appetite, and appeared calm during the day, but was very restless at night.

On the 22nd, at ten P.M., he contrived to baffle the vigilance of the nurse, and throwing himself down a flight of stairs, died about an hour after the fall.

The autopsy shewed that the immediate cause of death was a fracture of the cranium, with depression of the right parietal bone.

The only organic lesion discoverable was an enlargement of the spleen. Its colour resembled that of a healthy liver; it contained but little blood, and to the naked eye presented no textural modification.

We would here remark that, in this case, there was no hypertrophy of the liver or lymphatic glands; that the intestinal symptoms were but slightly marked; and that no indication of serous effusion could be detected.

We refer the reader to the *Gazette Médicale* for the details of this case, conceiving it necessary to quote here, merely that which relates to the composition of the blood.

" *State of the blood.*—The blood found in the right ventricle " was of a mahogany or rather of a brick-red colour; it was

" fluid, turbid, and appeared to be mixed up with small white " corpuscles, scarcely perceptible by the naked eye; it contained, moreover, a number of whitish clots, some of which " had a violet tinge, and resembled clots of curdled milk; " these clots escaped with the blood, and did not adhere to the " wall of the ventricles. The blood presented the same characteristics throughout the whole extent of the vena cava, " in the portal vein, and in the mesenteric and splenic veins. " It was only, however, in the vena cava and right ventricle " that large and numerous clots were found. In the portal " veins the blood presented simply a brick-red hue and a turbid " appearance. That contained in the left ventricle was of a " blackish colour, of a pitchy consistence, and but very partially " coagulated. It contained two or three clots of a violet " colour, similar to those found in the right ventricle. Several " veins of the extremities were opened, but none were found " obliterated by colourless clots."

Microscopic examination of the blood and of the spleen, by M. Robin.

" The blood found in the left ventricle contained the smallest " amount of white corpuscles, their proportion being inferior " to that of the red globules; there were no small fibrinous " clots, but a few lozenge-shaped crystals were found.

" The blood found in the right ventricle was of a brick-red " colour, bordering more upon white than upon violet; it " contained a somewhat larger amount of white than of red " globules. Of these white globules, some were free, while " others were entangled with a certain number of red globules, " forming small fibrinous clots. Each of these clots was composed of a small mass of fibrin, one portion of which presented " a well-defined granular fibrillous structure, and the other a " series of homogeneous layers simply striated.

" The following were the peculiar characteristics of the " white globules; the red globules presenting nothing abnormal, require no special notice.

" We shall first describe:

" A. The globulins of the blood; and then

B. The white globules properly so called.

" A. *The Globulins.*—While relatively speaking scanty, they
" are, however, far more numerous than in health. Thus, as
" many as ten or fifteen are met with at once on the field of
" the microscope, whilst in general we see no more than one
" or two. They present, however, the same characters as in
" healthy blood; their diameter is always from 0.005 to 0.006
" of a millimètre;* they have a fine granular texture, and are
" void of nuclei.

" B. *The white Globules.*—Of these we distinguish two
" varieties:

" 1. White globules which retain their normal characteristics,
" being perfectly spherical and finely granular. Some
" of these present a rather large number of granulations of a
" blacker colour, with a clearer centre and a well-defined outline.
" All the globules of this description possess one important
" characteristic, which serves to mark their healthy
" condition, viz., the absence of nucleus. Their diameter varies
" from 0.008 to 0.009 of a millimètre.

" 2. White globules, differing from those met with in health
" by the presence of a nucleus. These globules differ from the
" preceding in point of size, their diameter varying from 0.009
" to 0.014 of a millimètre; many of them, moreover, have a
" less regularly spheroidal shape. What, however, serves specially
" to distinguish them, is a spherical and sometimes
" ovoid nucleus, the diameter of which varies from 0.004 to
" 0.005 of a millimètre. This nucleus contains minute granules,
" but no nucleolus properly so called. Between the nucleus
" and the outer covering of the globules, either fine molecular
" granules are observed, analogous to those met with in healthy
" white globules, or darker granules with a clear centre.

" The nucleated are much more abundant than the non-nucleated
" globules. Acetic acid gives the nuclei a reddish
" tint, and when placed in contact with the non-nucleated
" white globules, it produces a coagulation and separation of

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* A millimètre is about $\frac{1}{25}$ of an inch.

" their contents into two or four nuclei, smaller than those
" above described; these nucleoli likewise present a distinct
" reddish tinge. (With respect to the action of acetic acid
" upon the white globules of the blood, as contrasted with its
" action upon pus, see Ch. Robin's *Comparative Examination*
" *of the Stains of Blood, Rust,* etc.; in Briand, Chaudé, and
" Gaultier de Claubry's *Manual of Forensic Medicine,* fifth
" edition, Paris, 1852.)

" The most striking difference existing between the globules
" just described and those met with in health, consists in the
" former having a nucleus, which is either wanting in the
" latter, or is met with only after they have been acted on by
" water. We must further notice, as a morbid appearance, the
" large size of the white globules and of their nuclei.

" In the blood of the right ventricle, there were found mixed
" with the white globules, a large number of white, regular,
" lozenge-shaped crystals, of a reddish-yellow colour. These
" crystals were likewise very abundant in the tissue of the
" spleen, where they were found in considerable masses, al-
" though invisible to the naked eye.

" In the spleen, there were likewise found a large number of
" epithelial pavement-cells with rounded angles, varying from
" 0.012 to 0.015 of a millimètre in diameter, and having a
" spherical nucleus, without nucleolus, of from 0.005 to 0.007
" of a millimètre in diameter. These cells were readily distin-
" guished from the white globules with which they were inter-
" mingled, by their polyhedral form, and also by the action of
" acetic acid, which rendered them much less transparent, and
" did not impart a reddish tinge to the nucleus."

At the close of their memoir, MM. Charcot and Robin append a list of twenty-six cases of leucocythæmia, which we here quote.

CASES OF WELL-AUTHENTICATED LEUCOCYTHÆMIA. (UHLE.)

1. See Virchow, *Fror. N. Not.*, No. 780, 1845; U. *R. Ver. Zig.*, No. 34, 1846; U. *Schem. Jahrb.*, Bd. 57, p. 181.

2. Bennett, } *Edinb. Journ.*, Oct. 1845; et *Schm. Jahrb.*, Bd. 50,
3. Craigie, } p. 365.

4. Fuller, *The Lancet*, July and Oct. 1846.
5. Wintrich (Virchow), *Pr. Ver. Zt.*, t. 1847 ; *Schm. Jahrb.*, Bd. 59, p. 182.
6. Virchow, *Peinhardt's und Virchow's Archiv.*, Bd. 2, p. 587.
7. Vogel, *idem*, Bd. 3.
8-23. Bennett (Robertson, Parkes, Fuller, etc.), *Monthly Journal.*
24-26. Virchow, *Archiv.*, V. 1.

We here conclude the chemico-pathological history of the blood. In the preceding pages, our object has been to shew the actual state of science, and to point out the voids which still remain to be filled up, before we can complete a satisfactory system of human hæmatology.

These voids are numerous. In the first place, chemically speaking, the nature of the extractive matters of the serum, which doubtless play an important part, both in a physiological and pathological point of view, is almost unknown. Here, however, it is not improbable, will be found the key to many phenomena which we are at present unable to explain, more particularly as regards the metamorphosis of the elements absorbed by the blood.

With regard to the organic and inorganic salts of the blood, we as yet barely possess an outline of their history.

We are still ignorant of the best method of ascertaining, with the greatest accuracy, the weight of the globules.

The fatty matters have been very little investigated.

The presence in the blood, of those immediate principles, of which its more important constituents are composed, has been scarcely alluded to; while their existence even has been doubted.

Lastly, the changes which take place in the blood during respiration, and under the influence of the formation and disintegration of tissue, are still wrapt in much obscurity.

On the other hand, and considering merely the analytical processes with which we are acquainted, to how many morbid conditions have they yet to be applied ? How many acute and chronic diseases remain, in which the changes taking place in the blood are still a mystery ?

These are so many problems which remain to be solved, and to us it would be a source of much gratification, should the history of the blood which we have just traced, lead other physico-chemists to tread the same path. On this point, however, we have many doubts, nor are we loth to declare that pathological chemistry, such as we understand it, is comparatively little cultivated in France; and that, in this respect, our countrymen are far from possessing the energy of our English and German medical brethren.

CHAPTER III.

OF THE SECRETIONS FORMED BY THE CONGLOMERATE GLANDS:

NAMELY, THE SALIVARY GLANDS—LIVER—PANCREAS—KIDNEYS—VESICULI SEMINALES—MAMMARY GLANDS—LACHRYMAL GLANDS.

ARTICLE I.

OF THE SALIVA.

THE saliva has been made an object of considerable research, and yet science is still much in arrear respecting it.

The ancients were acquainted with but one species of saliva, viz., the mixed product resulting from the aggregate secretion of all the salivary glands. It is that which is expelled from the buccal cavity by the act of expectoration. It is easy, however, to perceive that this secretion has two distinct sources of origin, viz., the salivary glands properly so called, and the muciparous glands.

In 1780, De la Chenaie experimented, for the first time, upon the saliva of the parotid gland, as procured by section of the duct of Stenon in man.

Tiedemann and Gmelin (1827) admitted the existence of a pure saliva, the parotid saliva properly so called, and an impure or mixed saliva.

The experiments of MM. Majendie and Rayer, in 1846, shewed, that the parotid saliva of the horse differed from that found in the mouth of the animal, and that this latter alone possessed the property of transforming starch into dextrine.

In 1847, M. Claude Bernard made a series of curious experiments, by which he obtained separate specimens of saliva from the parotid, sublingual, sub-maxillary, and buccal glands.

Since then, these experiments have been repeated by Jacubowitsch, Ridder, Schmidt, Colin, and others.

We might point likewise to the ingenious experiments of Mialhe and Lassaigne, as well as to the useful analyses made by Simon, Lehmann, and others; but it is to the late researches of M. Claude Bernard that we are indebted for the greatest amount of information relative to the saliva, and to these researches, as published in the *Gazette Médicale*, we shall chiefly refer in the following chapter.

Up to a late period, anatomists and physiologists admitted the existence of two kinds of salivary glands. 1. The muciparous or mucus secreting glands, comprising the bucco-labial and lingual glands; and 2. The salivary glands properly so called, viz., the sublingual, sub-maxillary, and parotid glands.

According to the late researches, however, of M. Bernard, the true salivary glands, viz., the sub-maxillary, sublingual, and parotid glands, must be carefully distinguished from one another, both as regards their respective properties, and the uses of their secreted products.

We shall here consider the saliva in a chemical point of view only.

According to M. Bernard, four kinds of saliva are to be distinguished:

1. The mixed or buccal saliva;
2. The parotid saliva;
3. The sub-maxillary saliva;
4. The sublingual saliva, to which must be added the product of the bucco-labial glands and of the gland of Nuch.

SECT. I.—Of the Mixed or Buccal Saliva.

A large amount of saliva may be obtained in a short time by tickling the velum palate, so as to produce a slight tendency to vomit; this immediately causes a considerable flow of saliva into the mouth. A similar result may be obtained by the effort of yawning.

This mixed saliva is a compound formed by the combination, in varying proportions, of the secretions of the different salivary glands. It is a frothy, slightly turbid fluid.

Left to itself, it separates, according to M. Claude Bernard, into three parts:

1. A supernatant frothy fluid, more or less abundant;
2. An intermediate fluid portion, which is less viscid and more transparent than the former;
3. Below this latter, a greyish white deposit is formed, in which the microscope discloses epithelial cells, mucus globules, fat globules, the detritus of aliment, such as muscular fibre, vegetable cells, crystals of carbonate of lime, and vibriones resulting from the decomposition of portions of food remaining between the teeth. These latter substances are accidental, and form no constituent part of the saliva.

The filtered saliva is a clear, limpid, somewhat viscid fluid, which froths when shaken.

Its specific gravity varies from 1.005 to 1.008.

Its natural reaction is alkaline.

Saliva, once ejected from the mouth, rapidly changes, more especially during hot weather, and acquires a disagreeable odour.

It becomes acid under certain circumstances, more especially when it has not flowed for some time, as happens during fasting and after much speaking. This acidity is as much a normal as a pathological condition.

Many reasons have been assigned for this acidity of the saliva. Of all these, that of M. Bernard appears the most probable. He believes it to be due to a change in the organic matters, which coming into contact with the air on the surface of the buccal mucous membrane, undergo some kind of fermentation; possibly the lactic, as the presence of small particles of food on the tongue and between the teeth would favour this species of fermentation.

Chemical Composition.—The saliva in man, the horse, and the dog, is composed, according to M. Cl. Bernard, of the following matters:

1. Water;
2. Organic matters;
3. Organic and inorganic salts.

Water.—The proportion of water varies but little, being, in man, 992.90 according to Berzelius; 991.22 according to Simon; 988.10 according to Tiedemann and Gmelin; 995.16 according to Bidder and Schmidt; and 986.50 according to Lheritier. This latter authority asserts that the saliva of children contains a larger amount of water than that of adults, but this statement has not been confirmed by the analyses of others.

The water of the saliva increases in chlorosis, according to Lheritier (990 per 1000). It diminishes in the phlegmasiæ (968.90) and in mercurial salivation (974.00 according to Brugnatelli, and 970.00 according to Lheritier).

As the proportion of water may readily vary under physiological circumstances, it is evident that further analyses are requisite to confirm the foregoing assertions.

Organic Matters.—According to M. Claude Bernard, the following organic matters are found in the saliva:

1. Albumen;
2. Casein;
3. Epithelial cells;
4. A small quantity of phosphoretted fatty matters;
5. Mucus;
6. A peculiar organic matter.

Albumen.—The saliva of man contains a very small quantity of albumen. Hence, heat renders it somewhat turbid, owing to the coagulation of this substance. The saliva of the horse contains more albumen than that of man. Its exact proportion has not been definitely ascertained.

Epithelial Cells.—The presence of epithelial cells is one of the peculiar characteristics of mixed or buccal saliva. It is in that of man that they are found to be most abundant. According to Jacubowitsch, their proportion in the residuum of 1000 parts of human saliva, is from 1.64 to 4.84. These cells are large, flat, and polygonal, they contain one or two nuclei, and in their greatest diameter measure from $\frac{4}{100}$ to $\frac{7}{100}$ of a millimètre.

Mucus Globules.—These are found in abundance in human saliva. They present the appearance of round cells, containing one or more nuclei, and measuring about the $\frac{12}{1000}$ of a millimètre in diameter. According to M. Claude Bernard, they are accidental products, due to the irritation which the buccal mucous membrane experiences from being constantly in contact with the air and foreign matters.

Fat is found in small quantity in human saliva. It appears under the microscope in the form of fat droplets. According to Tiedemann and Gmelin, this fat contains phosphorus.

Of the Mucus and Organic Matter of the Saliva.—Numerous characteristic attributes have been assigned to these substances, respecting which, authorities are far from being agreed. M. Claude Bernard, in his memoir on the saliva, has drawn up a table, in which he quotes the various opinions given by all those who have investigated the nature of these substances. We would recommend the reader to refer to this table, which we are unable here to reproduce.

The table itself clearly demonstrates the uncertainty which exists relative to the characteristics of what has been termed, the mucus and specific organic matter of the saliva. Upon no single point, in fact (solubility, action of acids, etc., etc.), are authorities as yet agreed. According to MM. Budge and Blondlot, the salivary mucus is soluble in water; while all other chemists hold the contrary opinion. Tiedemann, Gmelin and others assert, that acetic acid converts the mucus into a soft transparent mass. Berzelius and many others, on the contrary, maintain that this acid contracts the mucus and renders it opaque. The specific organic matter of the saliva is a source of still greater confusion, its name even, being as yet not decided upon. Berzelius, Simon, and others, have termed it *ptyaline;* Tiedemann, Gmelin, and Burdach, *salivary matter;* and Mialhe, *salivary diastase.*

It is usually considered to be soluble in water and insoluble in alcohol.

Blondlot, Mialhe, and Gmelin, admit that heat, tannin, and the metallic salts precipitate this substance; Berzelius and Simon, however, assert the contrary. According to M. Claude Bernard, these differences of opinion depend upon the variety of means employed to investigate the nature of the saliva, and to the changes which it undergoes before being made the subject of analysis.

Of the Inorganic Matters of the Mixed or Buccal Saliva.—According to M. Claude Bernard, the following inorganic substances exist in the saliva:

1. Alkaline carbonates;
2. Earthy phosphates;
3. Chlorides;
4. Sulphates and lactates;
5. And lastly, according to some authorities, the sulphocyanide of potassium.

Alkaline Carbonates.—According to several chemists, and especially Lehmann, free potash, soda, and lime, exist in the saliva, and become converted into carbonates, only after being excreted and brought into contact with the air. M. Claude Bernard, however, does not admit this, having proved by experiment, that the parotid saliva contains carbonates previous to contact with atmospheric air. He bases his views, moreover, on the fact of the parotid saliva of the horse containing a larger amount of carbonates than the mixed or buccal saliva. He asks whether the disappearance of these salts upon contact with the air, may not be due to a decomposition, causing a precipitation of the insoluble carbonates. This, according to M. Bernard, would explain the presence of crystals of carbonate of lime, frequently met with in the mixed saliva obtained by scraping the dorsum of the tongue.

Phosphates.—The phosphate of soda is found in the buccal saliva. In 100 parts of incinerated human saliva, Enderling found 28.122 of phosphate of soda, and Jacubowitsch as much as 51.1 per cent.

The proportion of phosphate of lime is but small. According to Fourcroy and Wollaston, the salivary calculi occasionally observed in man, are almost entirely composed of this salt.

To the presence of this salt is attributed the deposition of tartar upon the teeth. This tartar is a very complex substance; it contains epithelial cells, mucus globules, fat globules, certain infusoria, phosphate of lime (from 60 to 80 per cent.), and a small quantity of carbonate of lime.

The formation of tartar has been variously explained. Some consider it to be caused by the evaporation of the saliva. The following, however, is M. Dumas' theory. There are two species of saliva, the one acid and the other alkaline. The latter saturates the former, which holds the phosphates in solution until it loses its acid qualities, when the salts are at once deposited, and thus form the tartar.

This explanation, as is justly remarked by M. Bernard, does not account for the great disproportion existing between the saliva, which contains but a trace of phosphates, and the tartar, which contains from sixty to eighty per cent.

M. Bernard suggests a more probable explanation, and considers the tartar to be due to an alveolo-dental irritation, produced by the shrinking of the gums, previously softened by the contact of alimentary matter during the process of mastication. He founds his opinion upon some experiments made on animals.

Alkaline Chlorides are found to a certain extent in the saliva of man; while some have admitted the existence of lactates and sulphates; together with traces of silica.

Sulpho-cyanide of Potassium.—This substance has been considered as one of the characteristic elements of the saliva, and its existence has given rise to numerous discussions.

It was first pointed out by Treviranus, but was subsequently demonstrated more clearly by Tiedemann and Gmelin, who based their views respecting its presence in the saliva, upon a certain number of chemical reactions. They did not, however, succeed in isolating the salt.

The proportion of sulpho-cyanide of potassium met with in human saliva has been variously estimated. Jacubowitsch places it at 0.006 per cent. ; Wright, at from 0.070 to 0.098 per cent. ; and Lehmann, at from 0.0046 to 0.0089 per cent. The presence of sulpho-cyanide of potassium in the human saliva has been admitted by Tiedemann and Gmelin, Wright, Mitscherlich, Dumas, Jacubowitsch, and Lehmann, but denied by Schultz.

According to certain authorities, it is the result of some pathological condition : thus, Lehmann found a small quantity of ptyaline, but a large amount of sulpho-cyanide of potassium, in a case of mercurial salivation with considerable swelling of the buccal mucous membrane. It disappeared, however, as soon as this membrane recovered its natural appearance, and the saliva, its limpidity.

The spontaneous change which the saliva undergoes, does not appear to have any effect on the production of this salt.

M. Claude Bernard agrees with Berzelius in denying the preexistence of the sulpho-cyanide of potassium in the saliva; they both, however, admit that it may be developed under certain accidental circumstances. The former observer considers it impossible, as yet. to determine these conditions ; but from some experiments mentioned in his paper on this subject, he appears willing to admit that the presence of the sulpho-cyanide of potassium in the saliva, may be due to the carious state of one or more teeth, and that it would be found absent in those whose teeth were perfectly sound.

The presence of so poisonous a salt in the saliva has given rise to a variety of somewhat improbable hypotheses. Thus, according to some physiologists, an increased formation of the sulpho-cyanide of potassium would explain the development of hydrophobia, which is transmitted by the inoculation of the saliva of animals affected with this disease (Wright).

Hitherto, these views have not received confirmation, being based upon inconclusive experiments. According to Eberle, the formation of sulpho-cyanide of potassium in the saliva, depends, like hydrophobia, upon a certain condition of the nervous system ; and he states that under the influence of depressing emotions, saliva previously affording no traces of the salt in question, will now give indications of its presence.

Such is the history of the mixed or buccal saliva, as we have been enabled to trace it with the assistance of the three interesting memoirs of M. Claude Bernard, recently published in the *Gazette Médicale.** They appear to constitute a complete summary of all that chemistry and physiology have made known respecting this species of saliva.

To render this chapter as complete as possible, we shall conclude by quoting a few quantitative analyses of healthy and morbid saliva. Although made previous to the researches of M. Bernard, they are not without interest.

Analysis of healthy saliva. (*Simon.*)

Water	991.225
Solid matters	8.775
Fat containing cholesterine	0.525
Ptyaline and extractive matters	4.375
Extractive matters and salts	2.450
Albumen, mucus, and cells	1.400

Berzelius has given the following analysis of 1000 parts of human saliva:

Water	992.9
Ptyaline	2.9
Mucus and extractive matters	1.4
Lactates	0.9
Chloride of sodium	1.7
Soda	2.2

The following is the analysis of Tiedemann and Gmelin:

In 1000 parts of saliva there are from 9 to 11.4, and even 11.9, parts of solid matters. The composition of which is as follows:

Fat, containing phosphorus Extractive matters Chloride of potassium Lactate of potash Sulpho-cyanide of potassium	31.25

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* *Gazette Médicale,* 1853, Nos. 7, 11, and 12.

Undetermined animal matter, with traces of sulphates and alkaline chlorides	1.25
Ptyaline with phosphate of soda, chloride of sodium, and sulphate of soda	20.000
Mucus, a small quantity of albumen, with phosphates and alkaline carbonates	40.00

100 parts of solid residuum, when incinerated, gave 21.9 of inorganic constituents, 17.2 of which were soluble salts.

Mitscherlich found from 14.7 to 16.3 of solid matters in 1000 parts of human saliva. Dr. Wright has given the following analysis:

Water	988.1
Ptyaline	1.8
Fatty acids	0.5
Chlorides of potassium and sodium	1.4
Albumen and soda	0.9
Phosphate of lime	0.6
Albuminate of soda	0.8
Lactate of soda and potash	0.7
Sulpho-cyanide of potassium	0.9
Soda	0.5
Mucus and ptyaline	2.6

According to M. Lheritier, the saliva contains:

Water	986.5
Organic matter	12.6
Inorganic matters	0.9

The same chemist asserts, that the saliva of children contains a larger proportion of water; in support of this statement he gives the mean of four analyses, thus:

Water	996.5
Organic matter	3.5
Inorganic matter	0.5
Ptyaline	1.1

According to Enderlin, the combination of several specimens of saliva gave the following proportions in one hundred parts of salts.

Matters soluble in water.

Tribasic phosphate of soda . .	28.122	92.367
Chlorides of potassium and sodium .	61.930	
Sulphate of soda	2.315	

Matters insoluble in water.

Phosphate of lime	5.509
Phosphate of magnesia	
Peroxide of iron	

Of the Pathological Conditions of the Saliva.—Previous to the researches of M. Bernard, science already possessed certain documents relative to the pathological conditions of the saliva. Of these we shall now speak, remarking, however, that the different methods of analysis adopted by the authors, prevent us from comparing their results, and deducing general principles from them, as we have been enabled to do in the case of the blood and urine.

The saliva may undergo certain changes relative either to its physical qualities or to its chemical properties.

PHYSICAL QUALITIES—*Quantity.* The quantity of the saliva increases under the influence of moral emotion, and of certain special conditions of innervation. A salivary flux may accompany various diseases; thus it is met with in the various forms of cynanche and in parotitis; it is very common also in variola.

Certain therapeutic agents produce a flow of saliva; such as pyrethrum, tobacco, pimento, and especially mercury.

The flow of saliva is sometimes arrested in certain conditions of the nervous system. Such a result may be the consequence of terror, or of any other violent emotion. The saliva, in this respect, being amenable to the same laws which regulate the various fluxes to which the organism in general is liable; such, for instance, as diabetes, polydipsia, profuse diarrhœas and diaphoresis.

In the death struggle, the flow of saliva is almost entirely arrested, it becomes viscid and adheres to the lips.

Density.—This is generally proportionate to the amount of saliva, and to the frequency of its expulsion. It increases when the saliva is scanty, and diminishes when abundant.

Odour.—The saliva frequently acquires a disagreeable odour. Thus, in dental caries, in inflammation of the gums, in mercurial stomatitis, in scurvy, and in pseudo-membraneous angina, the saliva almost always has a disagreeable smell. The same result may even be produced by mere gastric derangement.

Consistence.—This is generally in inverse ratio to the abundance of the saliva.

Colour.—The colour of the saliva may be altered by the introduction of various foreign substances. Pus and blood are the two organic fluids by which it is most likely to be contaminated; the former renders it lactescent, the latter gives it a reddish tinge.

Chemical Modifications.—The following is a *resumé* of certain comparative experiments made by M. Lheritier. We quote them in a tabular form, for convenience sake.

	In health.	Mercurial Salivation.	Chlorosis.	Bright's disease.	Inflammation, mean of six analyses.
Water . . .	98.65	97.09	99.00	98.59	96.89
Organic matters .	1.26	2.80	0.07	1.36	3.09
Inorganic matters	0.09	0.11	0.03	0.05	0.11

It would appear from this table:

1. That in mercurial salivation, there is a decrease of the water and salts, and an increase of the organic matters.

2. That in chlorosis, there is a considerably increased proportion of water, and a great decrease of the organic matter and salts.

3. That in Bright's disease, the saliva gradually loses its normal composition; the salts decrease, and the organic matters undergo a trifling augmentation.

4. That in the phlegmasiæ, the proportion of water diminishes, while that of the salts and organic matters increases.

Simon has likewise published a few analyses of morbid saliva, some of which we shall here reproduce, leaving out of the question all that refers to the acidity or alkalinity of the saliva, having already alluded to this branch of the subject.

Mercurial Salivation.—In this pathological condition, Simon points out the presence of a large amount of liquified fatty matter and albumen. Thus:

Water	974.12
Solid matters	25.88
Viscid, yellow adipose matter	6.74
Ptyaline, with traces of casein	3.65
Alcoholic extract and salts	7.55
Albumen	7.77

Under similar circumstances, Dr. Wright found the composition of the saliva to be as follows:

Water	998.7
Ptyaline	1.9
Fatty acids	0.4
Albumen, soda, and albuminate of soda	0.6
Mucus, with traces of ptyaline	3.8
Lactates, phosphates, and muriates of potash and soda	2.4

The same author has given the following analyses of three specimens of morbid saliva:

	Fatty saliva.	Saccharine saliva.	Bilious saliva.
Water	987.4	986.9	986.7
Ptyaline	0.7	0.3	0.5
Fatty acids	3.9	0.2	1.3
Saccharine matter	...	5.6	...
Biliary matter	...	...	3.2
Cholesterine	...	...	0.4
Albumen, with soda and albuminate of soda	1.05	0.4	1.9
Sulpho-cyanide of potassium	a trace	a trace	a trace
Mucus	2.4	2.6	1.6
Lactates, phosphates, and muriates of potash, soda, and lime	1.8	1.9	2.3

Such is, then, the history of the mixed or buccal saliva, considered in a physiological and pathological point of view.

We shall now follow M. Bernard in his investigations relative to the three remaining species of saliva: the *parotid*, the *sub-*

maxillary, and the *sublingual saliva.* Respecting these varieties we shall be much less explicit, inasmuch as their analysis is of very recent date, while, in a pathological point of view, nothing satisfactory is known concerning them.

Sect. II.—Of the Parotid Saliva.

Mitscherlich relates a case in which he was enabled to examine the parotid saliva of a man suffering from salivary fistula. We shall presently refer to the results obtained by this experimentalist.

In animals, several examinations have been made of the parotid saliva, as obtained by the section of Stenon's duct.

M. Bernard has lately published the results afforded by an analysis of the parotid saliva in six cases of fistula, and to his researches we are indebted for much valuable and interesting information.

Physical Properties.—Pure parotid saliva is by no means viscid. It is liquid, alkaline, and perfectly transparent, but on cooling becomes slightly opalescent, owing to the precipitation of a sub-salt.

The parotid saliva occasionally contains particles of greyish mucus, which are soon deposited; while, at the same time, there may be detected on the surface of the saliva, a white pellicle, which forms in the space of twenty-four hours.

The precipitate seen at the same time, is composed of carbonate of lime, which carries down with it an insoluble organic matter. The precipitation of carbonate of lime is owing to the fact of the bicarbonate of the saliva losing a portion of its carbonic acid upon contact with the atmosphere. It is this deposition of carbonate of lime which characterizes the parotid saliva, and distinguishes it from the sub-maxillary and sublingual saliva, which are likewise more viscid.

Density.—The density of the parotid saliva in man, has been stated at from 1001.0 to 1008.8 by Mitscherlich. Such variations may be met with in the same individual, and at very short intervals of time.

The parotid saliva is alkaline: this is an admitted fact. Its alkalinity never disappears, and is even more marked than in the case of the mixed or buccal saliva. Dr. Wright estimates the quantity of soda in the parotid saliva of man, at from 0.095 to 0.353 per cent. The degree of alkalinity may vary under certain circumstances. According to Mitscherlich, it is less marked at the commencement of the flow, becoming more alkaline as this flow continues, and in proportion as the food is hard and stimulating.

According to Tiedemann and Gmelin, the alkali of human saliva is potash and not soda, as is the case with the dog and the sheep. This assertion, however, requires confirmation.

The proportions of water and of solid organic and inorganic matters have been determined by various authorities.

According to Mitscherlich, there are from 98.532 to 98.368 of water, and from 1.408 to 1.032 of solid matters; and according to Van Seuten, 98.38 of water, and 1.62 of solid matters.

The solid matters are composed of organic and inorganic substances; but we possess no analysis of human saliva, capable of showing the relationship which these substances bear to one another.

The organic matters of the saliva are, according to M. Bernard:

1. A substance which coagulates at a high temperature, and is precipitated by tannin and the stronger acids; it has alternately been regarded as albumen and casein;
2. Certain undetermined organic matters, confounded under the name of *ptyaline.*

These matters exist, according to Lehmann, in combination with the alkali of the saliva, and are thus held in solution.

The inorganic matters of the saliva are:

1. Bicarbonate of potash;
2. Chloride of potassium;
3. Carbonate and phosphate of lime;
4. Sulpho-cyanide of potassium, as asserted by some authorities.

We know but little of the variations which may occur in the proportions of the water and solid matters of the saliva: all we can say is, that the saliva last secreted generally contains the greatest amount of water. It is proper, therefore, in endeavouring to obtain a correct analysis, to take into consideration the exact period at which the saliva has been obtained.

Albumen has been stated to exist in human saliva. The fact, however, has not been so clearly proved as in the case of the horse, in the parotid saliva of which, experimentalists have demonstrated the existence of from 20 to 24 parts of albumen in 100 parts of dry residuum.

Simon, Schultz, and others, admit the presence of casein, and the absence of albumen, in the saliva of the horse. In the human subject, this question has not as yet been determined.

M. Bernard admits, as the result of experiment, that this substance, which he regards as of a saline albuminoid character, exists but in very small proportion in human saliva. He believes, moreover, that it rapidly undergoes decomposition, and partially disappears before being mixed up with the buccal saliva.

The same authority denies the existence of the organic matter termed *salivary diastase,* in recently secreted parotid saliva.

The sulpho-cyanide of potassium has never yet been isolated; as in the case of the buccal saliva, its existence has only been ascertained by chemical reaction.

The saline matters found in the saliva of the parotid gland, differ from those of mixed saliva, merely in their proportions. The alkaline carbonates, however, are more abundant in the former.

To sum up, then; the saliva of the parotid gland, according to M. Bernard, differs essentially, when pure, from other kinds of saliva, in its physical qualities and in its great fluidity. This latter quality favours the deposition of the salts of lime, and renders the absorption of foreign matters comparatively easy. Such is not the case with the more viscid species of saliva.

We possess no satisfactory information relative to the pathological conditions of the parotid saliva.

M. Bernard not having as yet terminated his researches relative to the saliva, we are unable to treat here of the sub-maxillary and sub-lingual salivas, and can merely state that, from his previous experiments, there would appear to exist in the sub-maxillary saliva, a liquid organic substance, very analogous to that which is found in the parotid saliva (ptyaline), but which has hitherto been but very partially investigated. It differs, however, from the former, in being exceedingly viscid, thick, and glutinous. It communicates its viscidity to water, and appears to constitute the whole of the sub-maxillary saliva, minus the salts. Soluble matters, in general, are little influenced by this viscid saliva, but dissolve with the utmost facility in the parotid saliva.

According to MM. Robin and Verdeil, this substance when mixed with the parotid saliva, or with the albumen which accompanies it, and probably even with the organic matter of the mucus secreted by the buccal mucous membrane after having been in contact with the atmospheric air, acquires the property, like other organic substances, of causing starch to undergo saccharine fermentation. It is this complex matter which has been considered as an immediate principle, under the name of *salivary diastase,* since even when removed from the saliva it preserves its property of causing fermentation.

According to M. Bernard, the function of the sub-maxillary saliva is to facilitate, by its viscidity, the passage of the food from the mouth into the œsophagus.

ARTICLE II.

OF THE BILE.

The bile is a product secreted by the liver. Of all organic fluids, it is undoubtedly that of which least is known. We are almost entirely ignorant of the true nature of the chemical elements of human bile, and we are still more ignorant of the proportionate quantities of these elements. To give an idea of the limited knowledge which we possess respecting the composition of the bile, it will suffice to ask ourselves the following questions, and to see how far they admit of being satisfactorily answered.

1. *What are the physiological characteristics of healthy human bile?* With the exception of a few observations made in some cases of biliary fistula, we know nothing of these characteristics.

2. *Is the bile found in the dead body similar to that which exists during life. May not death, its retention in the gall duct, and its subsequent contact with the atmospheric air, completely alter its properties and composition?* In animals, we have reason to believe that some such change actually occurs, but we are utterly ignorant of what takes place in man under similar circumstances. It would appear from a case recently communicated by M. Aran to the Society of Hospital Physicians, that the bile undergoes great modifications when brought into contact with the air after death.

By a mistake, from which, however, no evil consequences arose, a small trocar, instead of being plunged into an hydatid tumour of the liver, was pushed into the gall bladder. There immediately issued a clear, transparent, nearly colourless liquid, containing merely a few cloudy flakes. Such a fluid as this is certainly far from resembling the bile found in the dead body.

As for the bile obtained in certain rare cases of biliary fistula, we may ask whether it be really healthy bile?

We are therefore, as before stated, almost entirely ignorant of all that pertains to the physico-chemical properties of human bile; and we see no reason to doubt, but that all that has been hitherto said respecting its composition and properties refers to bile already changed.

In order, however, to bring the present article up to the level of science as it now stands, we shall follow the example of those who have preceded us, premising that all we have to say is chiefly applicable to bile taken from the gall bladder of the ox.

SECT. I.—Of the Physical Properties of the Bile.

The bile is a yellowish green fluid. On the addition of nitric acid, it becomes first green, then blue, then red, and lastly yellow. It imparts a deep yellow tinge to linen. It is a viscid fluid, having a mean specific gravity of 1020. This is not, however, absolutely exact, inasmuch as it must depend, to a great extent, on the degree of concentration of bile in the gall bladder.

The bile has an exceedingly bitter taste.

Its odour on leaving the gall bladder is scarcely perceptible; but it subsequently becomes exceedingly nauseous and disagreeable.

Heat does not coagulate it; it froths on being agitated, and is readily soluble in water.

Its reaction is alkaline: this alkalinity depends on the presence of soda; it is sometimes, however, neutral.

Acidity of the bile is a very exceptional occurrence: it is doubtful, indeed, whether it ever takes place.

The microscope discloses:

1. Greyish molecular granules, having a diameter of one millimètre at the utmost, and endowed with a peculiar kind of motion, to which the term brownian is now applied. This molecular movement is met with in the bile to a greater degree than in, perhaps, any other liquid.
2. Yellowish green patches, due to the agglomeration of several of these granules.
3. Small particles of fatty matter, very distinct, but scarce.
4. Cylindrical epithelial cells, probably derived from the larger excretory ducts.

It has been supposed that the cholesterine was suspended in the bile: but, according to the recent researches of M. Chevreuil, this can no longer be admitted.

SECT. II.—Chemical Composition of the Bile.

The analyses of the bile, generally quoted in works on chemistry, are those of Thenard, Berzelius, Tiedemann, and Gmelin:

Analysis of M. Thenard.

Water	905.0
Albumen	42.0
Resin	41.0
Yellow colouring matter	2 to 10
Soda	5.6
Salts	4.5
Oxide of iron	a trace.

Analysis of Berzelius.

Water	904.4
Biliary and fatty matter	80.0
Mucus of the gall bladder	3.0
Osmazome Chloride of sodium and lactate of soda	7.4
Soda	4.1
Phosphates of soda and lime	1.1

Analysis of Tiedemann and Gmelin.

Water	915.1
Solid matters	84.9, these are as follows:

A volatile substance having the odour of musk;
Cholesterine;
Oleic and margaric acids;
Cholic acid;
Biliary resin;
Taurine;
Biliary sugar;
Colouring matter;
Osmazome;
A substance having the odour of urine when heated;
A substance analogous to albumen and gluten;
Mucus;
Cheesy matter;
Salivary matter;
Bicarbonate of soda;
Carbonate of ammonia;
Acetate of soda;
Acetate, margarate, and choleate of soda;
Sulphates and phosphates of soda and potash;
Phosphate of lime;
Chloride of sodium.

On casting a glance over these analyses, it is impossible not to be struck with their discrepancies; and we might at once surmise, had not more recent researches positively confirmed the fact, that the great majority of substances pointed out by authorities, and more especially by Tiedemann and Gmelin, are the products of decomposition of the principal constituents of the bile, under the influence of the re-agents and chemical operations to which the liquid is submitted during the process of analysis.

It is to M. Demarçay that we are indebted for having unveiled the mystery which surrounded the subject of the chemical composition of the bile, by reviving the notion that the bile is a soda soap: and, moreover, by satisfactorily proving the same.

According to M. Demarçay, the bile is a choleate of soda; but it would appear from the researches of M. Strecker, that two acids enter into its composition, and that it must be regarded as a choleate and cholate of soda.

The bile, then, is evidently a soap, having soda for its base, in combination with two acids, the choleic and cholic acids.

It contains, moreover, small quantities of cholesterine, perfectly crystallizable; oleic and margaric acids, existing probably in combination with soda; and diverse salts, having for their base, potash, soda, ammonia, and magnesia.

We find, likewise, a species of colouring matter, if not indeed two, according to Berzelius: the one is the yellow colouring matter, to which he has given the name of *bilifulvine;* and the other, the green colouring matter, termed by him *biliverdin.*

With regard to the proportions of these different substances, nothing is known as yet. We may, however, enter here into some details respecting them and the products to which they give rise, under the decomposing influence of chemical reagents.

When cholic acid, which constitutes the major portion of the bile, is heated to the boiling point with caustic potash, it is transformed into *glycocole* and a new acid, the *cholalic.* If the ebullition be prolonged, this cholalic acid is itself transformed into a resinous-looking substance, termed *dyslysine.*

Cholalic acid is readily crystalizable in alcohol and æther. It is but little soluble in water, but readily so in a solution of caustic alkali or of the alkaline carbonates; but the salts thus formed do not crystallize upon evaporation. If, on the contrary, a solution of potash be added to an alcoholic solution of cholalic acid, colourless crystals of cholalate of potash are precipitated.

Cholalic acid, when heated to a temperature of 200 degrees,* becomes converted into *choloidic* acid; and when the temperature is raised to 400 degrees, it is transformed into *dyslysine*.

The second acid of the bile, viz., the choleic, has not been hitherto obtained in a state of purity. It contains much sulphur. Boiling caustic alkaline solutions convert it into cholalic acid, and into a new substance, called *taurine*, which is perfectly crystallizable. This latter substance (*taurine*) is likewise formed when bile is boiled with hydrochloric acid. Taurine is soluble in boiling water, but almost insoluble in pure alcohol.

In order to obtain choleic acid, the following simple process is recommended by M. Demarçay.

The bile is first to be evaporated, and the residuum treated with strong spirit, so as to prepare an alcoholic extract of bile. It is in this that the choleate of soda is found. The extract having been dissolved in 100 parts of water, two parts of sulphuric acid diluted with ten parts of water are to be added; the acid seizes the soda and liberates the choleic acid. On evaporation, the choleic acid may now be obtained in the form of a magma, containing a certain amount of colouring and fatty matter, from which it requires to be freed.

M. Strecker was the first to detect the presence of two organic acids in the bile. One of these contains nitrogen, but no sulphur; this is the cholic acid. The second, or choleic acid, contains both nitrogen and sulphur.

M. Strecker has succeeded in isolating cholic acid. It crystallizes as well as the cholate of soda. This latter is altogether formed in the bile, and may even be obtained by simply decolorizing that fluid with animal charcoal, evaporating, redissolving in pure alcohol, and then adding æther.

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* Centigrade measurement.

The choleic acid, however, has not been isolated by Strecker.

Mucus.—The bile contains a certain proportion of mucus, which may be precipitated by the addition of acetic acid or alcohol.

Cholesterine.—Is always found in bile, and forms the basis of all biliary calculi. It may be obtained by treating the extract of bile with æther; this takes up the cholesterine along with some fatty matter, which may be separated by again treating the cholesterine with boiling alcohol.

The cholesterine is held in solution by the choleate and cholate of soda, which possess the property of entirely dissolving fatty matter.

Saponaceous Fatty Acids.—These are the oleic and margaric acids, which are, like the cholesterine, held in solution by the choleate and cholate of soda.

Colouring Matters.—These are, as we before stated, two in number, viz., *biliverdin* and *bilifulvin*, the former of which is precipitated by chloride of barium, and the latter by baryta water.

Many chemists assert that the bile contains but one species of colouring matter, viz., biliverdin. Such is also the opinion of MM. Robin and Verdeil.

According to these authors, biliverdin is an organic substance, characterized by its colour, which varies from greenish yellow to dark green, occasionally bordering upon reddish brown, according to its degree of fluidity or concentration. It is this principle which is found in the serum of the blood in jaundice, and which imparts the peculiar yellow tinge to the fluids and tissues of those who are the subjects of this disease.

In the living organism, biliverdin is liquid. When rendered solid by the process of extraction, it appears as a blackish green powder, insoluble in water, but soluble in alcohol and especially in æther. Its solution has a green colour, when seen by reflected light, and a dark or orange red colour, by transmitted light. Hydrochloric and sulphuric acids deepen its green hue, while acetic acid gives it a reddish green colour.

Biliverdin, in combination with cholesterine, mucus, and certain salts, constitutes the majority of biliary calculi. It never, however, imparts its colour to the crystals of cholesterine. It is either expelled from the system in conjunction with the fæcal matters, or is destroyed by putrefaction.

Bilifulvin is, according to Berzelius, a yellow substance composed of a double acid salt of lime and soda, in combination with an acid, which is insoluble in water and alcohol, pulverulent, of a pale yellow colour, and called bilifulvic acid. He does not, however, assert it to be one of the normal constituents of the bile.

MM. Robin and Verdeil deny the existence of this substance, and assert that the only colouring matter of the bile is *biliverdin*.

In biliary calculi, there is usually found, together with cholesterine, a colouring matter, which presents the following characteristics: it is solid, pulverulent, and heavier than water, in which it is insoluble, as also in alcohol, æther, and oils, but soluble in alkalies. It contains nitrogen, and evolves ammonia when exposed to the action of heat.

It may not be out of place to allude here to the chief chemical constituents of bile, as admitted by Thenard, Berzelius, Tiedemann, and Gmelin, but which it is evident are merely the product of certain reactions, taking place during the chemical operations necessary for the purpose of analysis.

Biliary resin of M. Thenard.—This is a product of the decomposition of choleic and cholic acid, when treated with hydrochloric acid. It is precipitated together with the choloidic acid of M. Demarçay. Were the action of hydrochloric acid more complete, the substance discovered and called by Berzelius *dyslysine* would be the result. This biliary resin is composed, according to M. Chevreuil, of the oleic and margaric acids, a fatty matter, not acid, and of three of the colouring matters of the bile.

Taurine was discovered by Tiedemann and Gmelin; it is, as we have before stated, produced by the action of hydrochloric acid upon the bile. It is formed at the expense of the cholic acid, from which it abstracts the nitrogen.

Picromel.—Picromel, according to M. Demarçay, is merely bile deprived of its colouring matter and mixed with the acetate of lead employed in the analysis.

Resinoid Principle.—This is, according to M. Blondlot, the essential principle of the bile; it is a species of extract decolorized by animal charcoal. It results, probably, from the method of analysis adopted by M. Blondlot.

Bilin.—This is merely a combination of choleate and cholate of soda.

Bilate of Soda.—This is the term given by Liebig to the bilin of Berzelius.

Glykocholate of Soda.—The name given by Lehmann to the cholate of soda, which he also designates as the *taurocholate of soda.*

In order to ascertain the true chemical composition of human bile, it would be requisite to make several quantitative analyses, according to the method mentioned above. The bile should be obtained from healthy individuals, an almost insuperable difficulty, unless it were taken from persons who had just suffered a violent death, or who had been the subjects of biliary fistula.

It would then be necessary to make the physiological data, thus obtained, the basis of analysis in different pathological conditions, as has been done with reference to the blood. Such a procedure would be fraught with interest; since the presence of bile in the blood, and the non-elimination of some one or other of its constituents, cannot but play an important pathological part, under a variety of circumstances. All this, however, has yet to be done. In the mean time, we shall quote some analyses, upon which we would warn the reader not to lay much stress, inasmuch as they are not made in accordance with that view which considers the bile as a soda soap. We think it our duty, however, to mention them, as there may still be some who are unwilling to adopt the ideas of M. Demarçay, or to follow out the directions which he has given relative to the study of the bile.

Bizio (*Brugnatelli Giornale*) has thus analyzed the bile found in the gall-bladder of a man affected with jaundice:

Oil	3.720
Stearine	8.613
Green resin	2.030
A hard, yellow, nitrogenized matter, soluble in alkalies; boiling hydrochloric Acid and alcohol	1.937
Erythrogene	4.157
Soluble hæmatin	3.148
Gummy saccharine, extract with colouring matter	1.978
Soluble albumen	7.282
Fibrin	11.348
Chloride of sodium	0.984
Phosphate of soda	1.340
Phosphate of lime	1.320
Peroxide of iron	0.532
Water	5.232

This eccentric production bears no resemblance to bile. Is it not rather a special morbid secretion accumulated in the diseased gall bladder? On this head, Simon, who quotes the case, gives no information. It is, however, evident, that if it really were bile, it must have undergone some very considerable modifications.

Scherer has likewise analyzed the bile in the case of a man who died of jaundice.

Analysis of 1000 *parts of bile.*

Water	859.6
Solid matters	140.4
Bilin	48.6
Bilifellinic acid	30.5
Fat	8.8
Biliary pigment	44.3
Salts	8.0

In fatty degeneration of the liver, the bile, according to M. Thenard, presents the aspect of an albuminous fluid. It loses its principal characteristics; and five-sixths of its solid residuum are composed of fatty matter.

We subjoin all that is known of the bile in disease.

SECT. III.—Of the Pathology of the Bile.

The ancients, and the moderns up to the commencement of the present century, laid much stress on the morbid conditions of the bile in the production of disease. To this subject we have already alluded in our dissertation on the blood, and shall therefore pass it over in silence, confining ourselves exclusively to that which the actual state of science admits of being established.

With reference to the secretion of bile, three essentially different conditions may be present:

1. The bile, although secreted as usual, is prevented from finding its way into the intestine by some obstacle existing in the biliary ducts: in this case, retention of bile takes place.

2. From some alteration of the tissues, or functional disturbance of the liver, the bile is no longer secreted.

3. The bile is secreted in too great quantity.

CASE I.—*The bile, secreted in proper quantity, is retained in the gall bladder, and in the excretory and secretory ducts.*

This condition produces jaundice, which usually accompanies the local symptoms occurring in connexion with the liver; the symptoms themselves depending upon the nature of the existing obstacle; such as hepatitis, circumscribed peritonitis, calculi, etc. This jaundice indicates that the bile, or at least its colouring matter, is diffused throughout the system and impregnates the tissues generally.

The problem as to whether the bile itself passes into the blood, has occupied the attention of chemists as well as of physicians; but it does not yet appear to have been thoroughly solved by either. To us, however, the question appears to admit of a tolerably satisfactory answer, if we carefully examine the component parts of the blood in such cases. Having already treated of this subject in a former section of this work, we shall merely give a *resumé* of our views, as previously expressed.

In that form of jaundice which arises from an obstacle to the flow of bile, the following substances are found in the blood:—1. A great amount of cholesterine; 2. A greatly increased proportion of the fatty acids in the state of soap (oleate and margarate of soda); and 3. A considerable quantity of the two colouring matters of the bile. The choleate and cholate of soda have not been found in these cases; but their existence cannot be denied, inasmuch as they have not been sought for.

We may therefore conclude that in jaundice, by retention of bile, we find the principal constituents of this secretion in the blood, where they appear to undergo a species of concentration; and although the choleate and cholate of soda have not been hitherto detected, we may fairly ask whether this concentration be not the cause of the jaundice?

CASE II.—*Owing to structural lesion or functional disturbance of the liver, the bile is no longer secreted.*

Its spasmodic jaundice, occurring as a consequence of some violent moral emotion, this condition is not unfrequently met with. The same phenomenon takes place as in the preceding case, viz., a concentration of the biliary matters in the blood. We likewise find a large proportion of cholesterine, together with an excess of both the oleates and margarates of soda and of the colouring matters of the bile. It would appear that to produce this concentration, the suppression of the biliary secretion must take place suddenly, as occurs in the preceding case. When, on the contrary, the suppression of bile is, if we may so speak, of a chronic character, this concentration of its elements in the blood no longer occurs, and jaundice appears only in exceptional cases. Thus, in cirrhosis of the liver, it is certain that a portion of the natural secretion of that organ is suppressed; yet jaundice is rarely present in these cases, nor do any facts demonstrate the concentration of animal soaps and colouring matter of the bile, in the blood of individuals suffering from the disease in question.

CASE III.—*The bile is secreted in too great abundance.*

This happens in all cases of biliary flux, and it may occur as a distinct disease under a variety of circumstances; such, for instance, as the abuse of stimulants in hot countries. It is not uncommon in these countries to find remittent and intermittent fever complicated with hyper-secretion of bile, and the disease is then termed *bilious remittent,* etc. We not unfrequently even meet with biliary fluxes as distinct affections, in our own temperate climates.

This hyper-secretion of bile may or may not be attended with jaundice. In neither case have we found the elements of the bile concentrated in the blood. The disease is simply, therefore, a functional derangement of the liver. It is evident, however, that jaundice cannot take place, unless at least the colouring matter of the blood has been deposited in the tissues; this is possible, but in the cases of which we speak, it must of necessity be deposited as soon as produced, for we have never met with it during the whole course of our analysis of the blood. We may further add that, in biliary fluxes, jaundice is comparatively rare.

There remains one peculiar action of the bile which we cannot here elucidate, by reason of the entire absence of all scientific information upon the subject, and yet which cannot but be of importance. It is the influence which diseased bile may exercise upon the gall bladder, the duodenum, and the intestines. We repeat, it is not improbable that many interesting pathological facts may eventually be discovered in this field of observation ; of which, however, at present nothing can be said, inasmuch as we are still unacquainted with the modifications of which the bile is susceptible.

SECT. IV.—Of Biliary Calculi.

Under certain circumstances, there are formed, in the bile contained in the gall bladder, or in the secretory and excretory hepatic ducts, certain more or less consistent deposits of various sizes, which have been denominated biliary calculi. Considered in the aggregate, these calculi are composed of a large amount of cholesterine, of colouring matter, and of a small proportion of oleate and margarate of soda.

The substances entering into the composition of biliary calculi, occur in very different proportions: some, indeed, may occasionally be altogether wanting.

The following are some of the constituents of biliary calculi:

1. Cholesterine, in more or less perfect crystals.
2. The colouring matter of the bile (the *cholépyrrhine* of Berzelius). It is of a brownish red colour. Upon the addition of nitric acid, it successively assumes a green, blue, violet, and red tint, and at last becomes decolorized. It is soluble in a boiling solution of caustic potash, to which it imparts a greenish brown colour.
3. A dark brown, almost black, pigment.
4. Choleate and cholate of soda. We are not, however, perfectly convinced of the presence of these two salts in biliary calculi.
5. Mucus and epithelium.
6. Earthy salts, more especially carbonate of lime.
7. Margarine and margarates; oleine and oleates.

The physical properties of biliary calculi present very considerable variations, more particularly in point of size. Their colour, consistence, and volume, depend upon their chemical composition.

Vogel, in his *Pathological Anatomy*, admits eight varieties of biliary calculi, which are as follows:

1. Fine precipitates of cholepyrrhine and crystallized cholesterine, imbedded in mucus, and mixed with epithelium, whose cells are sometimes incrusted.
2. Biliary gravel—minute concretions of the size of a hempseed or grain of sand; occasionally, many such concretions are united by mucus, so as to form a large mulberry-shaped calculus.
3. Soft biliary concretions, which, in a recent state, readily admit of being moulded between the fingers, and consist of crystalline depositions of cholesterine, between which there is bile-pigment.
4. Crystalline calculi, consisting, for the most part, of cholesterine; nearly colourless, transparent, with a crystalline

fibrous fracture, granular on the surface, and usually covered with minute crystals of cholesterine.

5. Dark calculi, of a reddish brown colour and earthy fracture which does not become bright by friction. These consist for the most part of bile-pigment. There is a variety of this species, which is of a dark brown, almost black colour, and exhibits a red, mulberry-like appearance. These calculi seem to consist of a peculiar modification of bile-pigment.

6. Calculi, consisting for the most part of carbonate of lime; they are crystalline, with rough surfaces, terminating in sharp angles, and sometimes of a brownish colour.*

7. Gall stones, of a whitish colour, with a saponaceous aspect, and a concentric laminated arrangement. These calculi, on being scraped, assume a polished appearance, and consist for the most part of cholesterine.

8. Gall stones, consisting of alternate white layers of cholesterine, and dark yellow layers of bile-pigment.

The two last kinds are by far the most common.

The following analyses, as quoted by Vogel, may serve to give an idea of the varying chemical composition of gall stones.

	1.	2.	3.	4.	5.	6.
Cholesterine	96	65	67	50	4	...
Bile-pigment	3	25	...	35		...
Mucus	...				89	...
Biliary matter	...	3	17	...		...
Calcareous salts	...	2	...	8	3	100 ?

The following analyses of biliary calculi are due to Glaube and Brande:

	Glaube.	*Brande.*		
		1.	2.	3.
Cholesterine	56	81.25	69.76	81.77
Biliary resin	8	3.12	5.66	3.83
Bile-pigment	15	9.38	11.38	7.57
Albumen, mucus, and soluble salts	...	...	...	3.83
Coagulated albumen	9	...	...	...
Biliary mucus	12	6.25	13.20	...

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* *Bouisson, de la Bile.* Paris, 1843, p. 220.

Von Bibra found 1 50.0 of alumina with iron, and 1 40.0 of carbonate of lime in a biliary calculus.

In a similar concretion, Witting likewise found a large proportion of carbonate of lime.

Bailly and Henry found, in a biliary calculus, the following:

Carbonate of lime, with traces of carbonate of magnesia	72.70
Phosphate of lime	13.51
Mucus, with a small quantity of peroxide of iron and bile-pigment	10.81

Simon, having analyzed a biliary calculus, found it simply composed of biliary resin, altered colouring matter, and some traces of cholesterine.

Bertazzi has stated copper to be a constituent part of biliary calculi. He found it in fourteen cases, in all of which the proportion of copper appeared to be in direct ratio to the amount of bile-pigment. In ten analyses of healthy bile, the metal was not detected once.

Heller* has likewise demonstrated the existence of copper in biliary calculi.

Schubler and Michel† found a biliary calculus to be thus constituted:

Yellow saponifiable fat	25
Red colouring matter	75

They regard this red colouring matter as a modification of bile-pigment.

The chemical composition and physical properties of biliary calculi being well known, we may next endeavour to explain their mode of production.

1. By the concentration of healthy bile; as when, for example, it remains stagnant in the gall bladder for a length of time. In this case the bile becomes concentrated by the re-

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* *Archiv. für physiolog. und patholog. Chemie*, vol. ii, p. 228.

† *Journal für prakt. Chemie*, vol. viii, p. 378.

absorption of its watery portion ; while the cholesterine, fatty acids, and colouring matter, being less soluble, are first separated and then precipitated. The precipitation of the choleate and cholate of soda, must be much more uncommon and altogether exceptional.

2. May not the bile, under certain circumstances, contain more cholesterine than in health ? Albeit not as yet proved, such a condition is by no means improbable. Concentration likewise of the colouring matter may sometimes take place.

In those rare instances, where biliary calculi are found chiefly composed of carbonate and phosphate of lime, the proportion of these salts has probably undergone an increase, and they have been deposited after concentration.

Lastly, the mucus, being increased in quantity, may contribute to agglutinate those constituents of the bile which are separately precipitated.

The above, it is true, are but hypotheses ; hypotheses, however, which in all probability are an expression of the truth.

The subsequent growth of biliary calculi is similar to that of urinary concretions : when once the calculus begins to form, it rapidly increases, by becoming a centre of attraction for the more insoluble elements of the bile.

Sect. V.—Of the Hepatic Sugar.

The important discovery of the sugar-secreting function of the liver, is due to a French physiologist, M. Claude Bernard. We shall endeavour here to give a brief summary of his views, based as they are upon undeniable facts.

According to M. Claude Bernard, the hepatic sugar is derived from two sources : 1. From starchy aliment ; and 2. From the liver itself, which, according to this author, is capable of forming sugar without receiving any such aliment from the blood of the portal vein.

The blood which enters the liver is not found to contain sugar, unless the animal experimented upon has been fed upon starchy or saccharine substances ; while, on the contrary, the blood which leaves the liver, invariably contains a certain amount of sugar, whatever diet the animal may have been subjected to, and even for some time after a total abstinence from food in general.

We not only find sugar in the blood which leaves the liver, but likewise in the tissues of the organ itself, in all vertebrate and invertebrate animals. The quantity of sugar, however, appears to be greater, in proportion as the animals occupy a higher position in the zoological scale.

The liver secretes sugar under the influence of the respiratory apparatus. The lungs, stimulated by the action of the inspired air, react upon the nervous centres, which reflect such action back towards the liver, through the medium of the spinal cord and the great sympathetic nerve.

Experiments prove, that by direct irritation of the origin of the great sympathetic nerve, it is possible to produce a hyper-secretion of sugar on the part of the liver, the excess of this substance passing off with the urine. If, as has been asserted, anæsthetics possess the property of producing saccharine urine, it is probable that they act in a similar manner; and if we admit that they may produce the phenomena of asphyxia, it follows that the sugar-destroying agent (the action of the lungs) being diminished, the unconsumed sugar must escape along with the urine.

Diabetes is due to an increased production of sugar on the part of the liver.

M. Bernard has proved by experiment, that as section of the pneumogastric nerves destroys the influence exercised by the nervous system upon the lungs, the stimulus of the air upon these organs is no longer transmitted to the brain, and under these circumstances sugar is no longer found either in the liver or the urine.

The more an animal breathes, the more oxygen does it consume, and the more sugar does it produce.

This action of the respiratory apparatus upon the liver, presents all the characteristics of a reflex act.

If respiration be maintained in a decapitated animal by artificial means, the liver continues to secrete sugar. Again, if air, mingled with any irritating vapour, be introduced into the lungs, we, ere long, detect the presence of sugar in the urine.

Experiments then enable us to modify the production of sugar at pleasure, but they cannot influence its destruction in the blood. Such is a summary of M. Claude Bernard's theory.

M. Vernois, with a view of ascertaining whether sugar could be found in the liver after death, and whether it disappeared in certain diseases but remained in others, analyzed the liver in one hundred and seventy-one cases, and has published the results in the *Archives de Médecine*. We shall subjoin a brief summary of these interesting researches.

Influence of Age.—According to M. Bernard, sugar may be found in the liver of the fœtus at about the fifth month, but seldom before that period. After the fifth month it continues to increase in quantity, so that there is always found a larger amount of sugar in the liver of adult animals than in that of the young.

The following are the conclusions arrived at by M. Vernois:

1. Age appears to exercise a certain degree of influence upon the secretion of hepatic sugar: its minimum being found between the period of birth and the age of two, and its maximum between the ages of twenty and thirty.

2. Sugar is found in the liver of the fœtus, but not so frequently as in that of adults, even after the fourth month of intra-uterine existence.

3. Sugar may be found in the liver of the fœtus and not in that of the mother, and *vice versâ*. This fact is as yet unexplained.

Influence of Sex.—According to M. Vernois, the secretion of sugar by the liver is in no degree influenced by sex.

Influence of Disease.—The majority of authors who have written upon this subject, MM. Cl. Bernard, Robin, and Verdeil, merely state, that possibly certain diseases may cause a temporary disappearance of the hepatic sugar. MM. Reynoso, Michea, and Dechambre, have lately asserted that it is not the production but the destruction of sugar which varies. It is thus that he explains the presence of sugar in the urine of animals in whom the origin of the pneumogastric nerve has been pricked, or who have been drowned, strangled, or subjected to the action of anæsthetics; also in the urine of persons affected with phthisis, chronic bronchitis, arthritis, pleurisy, hysteria, epilepsy, and, lastly, in the urine of the aged. Such are the pretensions of M. Reynoso. In some experiments, however, made by him at the Hôpital de la Pitié, the presence of sugar in the urine was admitted upon such slender testimony, that doubt remained in the minds of all the spectators.

In 140 cases, wherein the nature of the disease was noted by M. Vernois, he only found sugar fifty-six times. It is evident, therefore, that disease exerts an undeniable influence upon the secretion of hepatic sugar.

Duration of the Disease.—According to M. Vernois, the amount of hepatic sugar is in inverse ratio to the duration of the disease.

Nature of the Disease.—Its influence is undeniable, being amply confirmed by facts. According to M. Vernois, there are certain diseases, in the majority of cases of which, the liver contains sugar: as, for instance, epidemic cholera.

M. Bouchut has arrived at similar conclusions: having made a filtered decoction of the liver in twenty cases of cholera, he tested each specimen with Barreswill's solution, and found sugar in every instance in which the disease had been protracted, but none, on the contrary, in those in which it had proved rapidly fatal.

M. Vernois asserts, moreover, that in the majority of other diseases, the number of cases in which sugar may be detected in the liver is very much smaller: as, for instance, in the sclerema of new-born infants, in cerebral diseases, and in tubercular affections.

Sugar is seldom found in cases where the liver has undergone anatomical change. It is not destroyed by putrefaction.

Influence of Abstinence.—M. Bernard, while asserting that the liver itself may secrete sugar, without the ingestion of such alimentary substances as are usually considered necessary to its formation, nevertheless admits that prolonged abstinence may even produce complete disappearance of the sugar. This result (the formation of sugar without constituent materials) is the most unacceptable portion of his theory, and new experiments are requisite before it can be satisfactorily proved. M. Mialhe especially, believes that the formation of sugar cannot be independent of a saccharine or amylaceous diet.

An opportunity was afforded to M. Vernois of examining the liver of a young female, eighteen years of age, who died of marasmus, the result of a chronic affection of the stomach which had lasted six weeks. During the fortnight previous to her decease, the patient had taken no food, having been kept alive by injections of strong broth. The liver contained a large quantity of sugar. We cannot, therefore, positively assert, that abstinence causes the disappearance or decrease of the hepatic sugar.

Saccharine Diabetes or Glucosuria.—According to M. Bernard, diabetes, as we have before seen, consists of a hypersecretion of sugar on the part of the liver. As the excess of this substance cannot be destroyed in the blood, it passes into the urine, by which it is eliminated from the system.

In support of his theory, M. Bernard has artificially produced diabetes in animals. There are nevertheless certain facts which seem to invalidate his views; for instance, M. Bernard himself states, that the liver of a diabetic patient, which he examined, contained no sugar. In another patient, however, who died rapidly of the same disease, under the care of M. Rayer, the liver (which was, it is true, in a state of hypertrophy) contained 14¼ drachms of sugar.

M. Vernois has likewise examined the livers of two diabetic patients; in one of these he found traces of sugar, in the other, none.

The theory of M. Bernard, although bearing the stamp of probability, presents nevertheless, certain difficulties, which further experiments can alone remove. As long as the absence of sugar in the livers of a certain number of diabetic patients remains unexplained, his theory must be regarded as incomplete.

Practical Consequences deducible from a Study of the Bile and its Modifications.

The history of the chemical composition of this fluid is so little advanced, that it may appear out of place to allude even to this subject. We shall content ourselves, therefore, with pointing out some of the more prominent indications which appear to present themselves, and to hint at the conclusions which might possibly be drawn from more extended research.

Can the bile, we may ask, when passing in an altered condition into the intestine, interfere with duodenal and intestinal digestion? Can it prevent or modify absorption? Lastly, is it capable of exercising an injurious influence upon the mucous membrane of the intestines? All this is possible; nay, more, it is probable; but upon these points science has hitherto been silent.

In cases where, from some functional or nervous derangement of the liver, the bile is no longer secreted, chemical analysis has demonstrated the presence in the blood of the constituent elements of the bile. Here the indication is positive: the liver requires stimulation. But do we possess remedies capable of producing such an effect? Here again another query suggests itself. According to some authorities, calomel and rhubarb fulfil the indication in question; according to others, saline and irritating purgatives produce exactly the same result. A solution of this problem in therapeutics would not be without importance.

Again, we might ask, is it by a species of elective action on the part of the liver, that such and such a purgative acts by increasing the functional activity of the organ? or is it, that by irritating the intestine and augmenting its secretion, the irritation thus produced is propagated to the liver, and, by sympathetic action, produces an increased secretion of bile? Such hypotheses are probable, and appear to accord with ascertained facts.

In cases where the biliary constituents remain in the blood, by reason of an obstacle to the free course of the bile, and its consequent probable re-absorption, as well as in those cases where it is not duly secreted, we must also have recourse to purgatives, but with a different object in view, viz., 1stly, to encourage the formation of the biliary secretion, and thus to produce such an amount of *vis a tergo* as may serve either to destroy the obstacle, or to impel it still further into the biliary passages; and, 2ndly, in order to propagate to the biliary ducts the peculiar motion which purgatives excite within the intestines, and by which the impacted body (a calculus for instance) may be made to overcome the obstacle presented by the narrow calibre of the hepatic ducts.

When there is an increased secretion on the part of the liver, with biliary flux, if it escape freely, and if there be sufficiently copious bilious evacuations, no especial therapeutic indication presents itself. If, on the contrary, the bile while escaping in large quantities from the liver, remains in the intestines without being evacuated, experience proves, that colic, more or less severe, not unfrequently occurs. Here the indication is distinct, and purgatives must be given, not to increase the secretion of the liver, but to remove the bile accumulated within the intestines.

Does the known composition of biliary calculi, we may ask, afford any therapeutic indication? This is a question which has to a considerable degree occupied the attention of physicians. But we must here again ask, whether, except in cases where the calculus presents an obstacle to the free flow of bile (an obstacle which is indicated by hepatic colics), we are acquainted with the symptoms of biliary calculi? Do they afford any positive, undeniable evidence of their existence, recognized and admitted by physicians in general? They certainly do not; how then can we attempt to lay down the treatment of biliary calculus?

When once the hepatic colic has disappeared and the calculus no longer obstructs the flow of bile, it is of but little consequence, whether it has been broken up or has escaped into the intestine, as it is most probable that others remain behind in some part of the biliary apparatus; or if this be not the case, the composition of the bile is such, that new calculi will form ere long. It is in such cases that a specific treatment has been recommended, viz., the administration of æther, turpentine, the remedy of Durande, etc. It was thought that these substances passing into the blood and from thence into the bile, might disintegrate the calculus by dissolving the cholesterine. The hypothesis was simply absurd; and now that we know more of the formation of the bile and biliary calculi, as well as of the action of those remedies, to which a chemical property was gratuitously attributed, it is impossible to conceive that any practitioner should adopt such views.

In the present state of science, we are unacquainted with the means of introducing into the bile remedies capable of acting directly upon this secretion, or of modifying the composition of biliary calculi.

Is, we may ask, the theory of M. Bernard, relative to diabetes, confirmed by the treatment of this disease, or does it throw any light upon its therapeutic management? With regard to the former question, we may answer, that the measures hitherto found most successful against this, but too often incurable disease, seem rather to invalidate his theory, and afford no information respecting the nature of this affection.

There are two plans of treatment which have been more successful than all others, albeit they frequently fail.

The first consists in the complete suppression of starchy and saccharine aliment. It is certain that in some cases this method of procedure will produce the entire removal of sugar from the urine. If this be the case, it is very clear that the liver requires these materials in order to form sugar, and that if they be withheld, it ceases to produce an excess of this substance. For the time being, therefore, an apparent cure at least is obtained.

The second plan consists in the administration of alkalies, as recommended by Mialhe and Contour. This method of treatment is occasionally successful, more especially if adopted in connexion with the preceding one. This is a fact which we cannot but admit, and which neither confirms nor invalidates the views of M. Bernard, although it cannot indeed be explained by reference to his theory. We must regard it therefore as an acknowledged fact in therapeutics, purely empiric, but yet true.

With regard to our second query, viz., whether the theory of M. Bernard has hitherto led to a rational plan of treatment, we must answer in the negative. Whether it may yet do so, the future alone can decide.

ARTICLE III.

OF THE PANCREATIC JUICE.

The pancreatic juice has frequently been compared to the saliva. This view, supported by Leuret and Lassaigne, but rejected by Tiedemann and Gmelin, gave rise to a series of experiments, which threw great light upon the composition of the pancreatic juice. The researches of MM. Bouchardat, Sandras, Mialhe, and especially of M. Bernard, have satisfactorily established this point.

The pancreatic juice is alkaline, and has always been found so by MM. Sandras, Bouchardat, and Bernard.

It is colourless, limpid, viscid and glutinous; it froths when agitated; its taste is saline. It is coagulable by heat, as well as by nitric and hydrochloric acids. Its coagulation is complete, not a drop of fluid being left. The coagulum is white. The coagulable material is not precipitated, either by lactic, acetic, or diluted hydrochloric acids; but is entirely redissolved by alkalies.

The pancreatic juice undergoes decomposition with great facility; a few hours being sometimes sufficient to produce this result.

We do not conceive it necessary here to quote the analyses made by Leuret, Lassaigne, Tiedemann and Gmelin. In the present state of science they are no longer of importance.

The constituents of the pancreatic juice are as follows:

a. Water;

b. A substance constituting the major portion of the pancreatic juice, and which has been regarded as albumen by Tiedemann and Gmelin, and as casein by others.

c. Osmazome ;

d. Acetate of soda ;

e. Chloride of sodium ;

f. A small quantity of phosphate and carbonate of soda (with a little potassium) ;

Lastly, carbonate and phosphate of lime.

The coagulable matter of the pancreatic juice has been described by MM. Robin and Verdeil, under the name of *pancréatine.* The following are its chief characteristics.

It is a liquid which coagulates upon the application either of heat or alcohol; in the latter case, it may be re-dissolved in water; unlike albumen, it cannot be filtered through sulphate of magnesia, which coagulates it. This substance exists only in the pancreatic juice. It is coagulated, moreover, by concentrated nitric, sulphuric, and hydrochloric acids, as well as by the metallic salts and pyroligneous spirit. Diluted acetic, lactic and hydrochloric acids do not produce this result. Alkalies re-dissolve the precipitate. When treated with chlorine, the pancreatine presents a fine red colour. It putrifies rapidly at a temperature of from 40° to 50° centigrade measure (from 105° Fahrenheit).

It is of this substance that the pancreatic juice is almost entirely composed, and, by it, the salts which it contains are held in solution.

According to MM. Robin and Verdeil, this substance does not undergo rapid change in those cases where the pancreatic juice is of morbid quality. It disappears gradually, the pancreatic juice becoming more watery and losing its activity. Moreover, as soon as it begins to change, the saline principles, which, while insoluble in water were perfectly soluble in healthy pancreatic juice, are deposited. It is the pancreatine which possesses the property of forming an emulsion with fatty matters. When coagulated by alcohol, it still retains this property, provided it be re-dissolved in water.

The activity of the pancreatic juice is in direct proportion to its coagulability, or, in other words, to the amount of pancreatine which it contains.

Of the pathological modifications of the pancreatic juice, we know nothing.

ARTICLE IV.

OF THE URINE.

The urine is a fluid secretion eliminated by the kidneys. We shall proceed to investigate its physico-chemical properties, both in health and disease.

SECT. I.—Of the Physico-chemical Properties of the Urine, and of the proper kind of Urine for Examination.

The ancients very justly admitted a distinction between the various kinds of urine passed at different times of the day. This distinction is still recognized, and is as follows.

1. *Urina Potûs.*—They thus designated the urine passed after taking a certain amount of fluid. It is more limpid, of a lighter colour, and of a lower specific gravity than urine passed at other times.

2. *Urina Chyli.*—This is urine passed two or three hours after a meal, when digestion is either partially or entirely completed. It is much influenced by the quantity and quality of the food.

3. *Urina Sanguinis.*—This is urine passed on rising in the morning. It bears a certain relation to the composition of the blood, and is but little affected by the solids or fluids which may have been taken over night. It might not inaptly be designated as the pure product of the renal secretion. It is this urine which is usually chosen for examination when we wish to ascertain its composition, whether in health or disease.

There is a method, first employed by M. Chossat and subsequently by MM. Lecanu and Becquerel, which consists in collecting all the urine passed in the space of twenty-four hours, and then analysing the sum total of fluid thus obtained. We thus ascertain the quantity of urine passed in a given time, and this serves as a standard of comparison for subsequent experiments. By adopting this plan, moreover, we are enabled to compare the results of analysis as afforded by the urine passed by one person in twenty-four hours, with that passed by another in a similar space of time. The above method of procedure should be employed whenever it is possible to do so; the first specimen to be collected, being that passed on rising in the morning. When the produce of twenty-four hours cannot be procured, we must be satisfied with the morning excretion.

Sect. II.—Of the Composition of the Urine in Health.

The composition of the urine as passed in the twenty-four hours, varies, within certain limits, from day to day. To obtain therefore an exact mean, the urine of an individual must be analyzed for several days in succession.

The following table gives the mean composition of the urine in health, as ascertained by ourselves. The first column refers to the amount of urine passed in twenty-four hours, and in the second column the results are referred to the standard of 1000. Such a proceeding is indispensable, the second column serving more especially as a key by which to compare the results obtained by other chemists.

The table itself indicates the mean composition of healthy urine in the male and female, together with the mean deduced from their addition. It is based upon the results afforded by eight analyses of healthy urine.

CHEMICAL CONSTITUENTS OF THE URINE.	MALES.		FEMALES.		MEAN OF BOTH.	
	Urine passed in twenty-four hours.	Composition of 1000 parts of urine.	Urine passed in twenty-four hours.	Composition of 1000 parts of urine.	Urine passed in twenty-four hours.	Composition of 1000 parts of urine.
Amount of urine	1267.3	1000.	1371.7	1000.	1319.8	1000.
Specific gravity	1018.900	...	1015.120	...	1017.010	...
Water	1237.779	968.815	1337.489	975.052	1282.634	971.935
Matters resulting from direct evaporation	39.521	31.185	34.211	24.948	36.866	28.066
Urea	17.537	13.835	15.582	10.366	16.555	12.102
Lithic acid	0.495	0.391	0.557	0.406	0.526	0.398
Fixed salts at a red heat: Chlorides, Phosphates, Sulphates of Lime, Soda, Potash, Magnesia	9.751	7.695	8.426	6.143	*9.089	†6.919
Organic matters incapable of being separated: Lactic acid, Lactate of ammonia, Colouring matters, Extractive matter, Hydrochlorate of ammonia	11.738	9.261	9.655	8.033	10.696	8.647

* *Fixed salts contained in urine passed during the twenty-four hours.*

Sum total	9.089
Chlorine	0.659
Sulphuric acid	1.123
Phosphoric acid	0.417
Potash	1.708
Earthy and alkaline bases of Soda, Lime, Magnesia	5.181

† *Fixed salts contained in 1000 parts of urine.*

Sum total	6.919
Chlorine	0.502
Sulphuric acid	0.855
Phosphoric acid	0.317
Potash	0.300
Earthy and alkaline bases of Soda, Lime, Magnesia	3.944

M. Lecanu, in his numerous experiments, has arrived at almost analogous results. These, if calculated upon the same principle and referred to 1000, give the following proportions:

Specific gravity	1017.010
Water	937.975
Urea	13.074
Uric acid	0.410
Fixed salts not decomposed by heat	10.067

This latter number (10.067) differs, however, considerably from that which we have given in the preceding table, viz. 7.

Berzelius has framed a table which shews the composition of the urine, but it differs greatly from those of MM. Lecanu and Becquerel. This table, which for a length of time was accepted as a standard of comparison for the different researches made, of late years, upon the urine, was, in all probability, based upon experiments made on the morning urine. Deeming it unnecessary to allude further to the views of M. Berzelius, we shall proceed to investigate the properties and variations of each of the chemical constituents of the urine.

A. THE WATER.

There is no other method of accurately ascertaining the amount of water contained in the urine, but that which consists in evaporating the secretion in a stove at a temperature of 80 degrees (centigrade measure), and weighing the residuum: the loss by weight, shewing the amount of water.

To obtain an approximative notion of the quantity of water contained in the urine, as contrasted with the amount of solid matters which it holds in solution, we may employ a graduated aerometer, provided its value have been previously tested by repeated desiccations. The aerometer, however, merely gives the proportion of water and solid matters contained in 1000 parts of urine: but by a simple rule of proportion, we may pass from the standard of 1000, to the sum total of urine passed in twenty-four hours.

The following table is given by M. Becquerel in his *Sé-*

méiotique des urines: it affords an approximative estimate of the quantity of water, and shews how the specific gravity of the urine may be considered as an expression of the ratio existing between the water and the solid matters.

Specific gravities.	Water contained in 1000 grammes of urine.	Additional matters contained in 1000 grammes of urine.
1000.000	1000.000	0.000
1001.000	998 350	1.650
1002.000	996.700	3.300
1003.000	995.050	4.950
1004.000	993.400	6.600
1005.000	991.750	8.250
1006.000	990.100	9.900
1007.000	988.450	11.550
1008.000	986.800	13.200
1009.000	985.150	14.850
1010.000	983.500	16.500
1011.000	981.850	18.150
1012.000	980.200	19.800
1013.000	978.550	21.450
1014.000	976.900	23.100
1015.000	975.250	24.750
1016.000	973.600	26.400
1017.000	971.950	28.050
1018.000	970.300	29.700
1019.000	968.650	31.350
1020.000	967.000	33.000
1021.000	965.350	34.650
1022.000	963.700	36.300
1023.000	962.050	37.950
1024.000	960.400	39.600
1025.000	958.750	41.250
1026.000	957.100	42.900
1027.000	955.450	44.550
1028.000	953.800	46.200
1029.000	952.150	47.850
1030.000	950.500	49.500
1031.000	948.850	51.150
1032.000	947.200	52.800

Of the exact estimate, relative to the amount of water contained in the urine. This is a point of the utmost importance;

and it is from want of having been properly attended to, that the investigation of the urine has been so frequently said to yield no practical results.

If, in fact, we admit that the amount of solid matters held in solution is always the same, while that of the water varies, we must, of necessity, meet with specimens of urine endowed apparently with very different qualities, although containing the same chemical constituents, the only real difference being in the amount of water by which these latter are held in solution. An accurate estimate, therefore, of the proportion of water contained in the urine is indispensable to the analysis of this fluid.

The quantity of water passed in the twenty-four hours may be represented, on the average, by the following figures:

In the male	1227.779
In the female	1337.489
Mean of both	1282.634

In health, these proportions are liable to considerable variation. Thus, from 800 to 1500 of water may be considered as the physiological limits; the amount of solid matters held in solution remaining the same, or nearly so. This serves to shew the necessity for ascertaining the proportion of water, since the same quantity of solid material dissolved in 800 or 1500 parts of fluid, would constitute two very different kinds of urine, both as regards their appearance and their physical properties.

The quantity of water may increase or diminish.

Increase of the Water.—One physiological and three important pathological causes may contribute to this result.

The former consists in the introduction of a large amount of water into the system.

The latter, in the presence of one or other of the following morbid conditions: 1. Polydipsia; 2. Diabetes; 3. Hysteria, and some other nervous phenomena.

Decrease of the Water.—It may be caused by one or other of the following circumstances:

1. Fever and febrile affections generally;
2. Diseases of the heart and liver, sufficient to produce general perturbation of the economy;
3. Whatever diseases are capable of producing general functional disturbance;
4. Profuse perspiration;
5. The approach of death.

It is important to observe, that the amount of water introduced into the system can only be ascertained by collecting the urine passed in the space of twenty-four hours. Were we to be contented with referring the results otherwise obtained, to the numerical standard of 1000, no conclusions whatever could be arrived at.

It may be stated, as a general rule, that urine containing a large proportion of water is pale, clear, of low specific gravity, feebly acid, and copious; whilst that which contains but a comparatively small quantity, is dark, of high specific gravity, often deposits a sediment spontaneously, and is always diminished in point of quantity.

B. OF THE SOLID CONSTITUENTS HELD IN SOLUTION BY THE WATER.

The urine may be represented: 1. By the water; and 2. By the sum total of solid matters which this latter holds in solution. Before isolating the chemical principles which compose this sum total, it will be proper to consider them in the aggregate, and to ascertain how far this aggregate may vary.

The mean amount of solid matters held in solution may be represented in health by the following figures:

	Water.	Solid matters secreted in twenty-four hours.
Males	1227.779	39.521
Females	1337.489	34.211
Mean of both . . .	1282.634	36.866

The variations may be roughly represented as follows:

In males, from 36 to 41; in females, 32 to 36; mean, from 32 to 41.

The aggregate of solid matters may either increase or diminish.

Increase of the Solid Matters.—This may be the result of one or other of the following causes:

1. A nutritious, abundant, and highly nitrogenized diet.
2. The introduction into the system of an unusual amount of water.

According to the experiments of M. Becquerel, whenever a somewhat large amount of water is introduced into the system, it escapes by the kidneys; but these organs do not act the part merely of passive filters; they eliminate the water by an active process of secretion; whence it follows, that the function of the kidneys being increased, its operations cannot be confined to the water alone, but must necessarily include, in the increased secretion, a larger amount of solid matters.

This law explains the constitutional debility which attends profuse discharges of urine: such as occur, for instance, 1. In polydipsia, in a case of which, M. Becquerel found the aggregate of solid matters to be as high as 43.659; 2. In the urinary discharges which take place under the influence of certain morbid conditions of the nervous system, and more especially in hysteria, in which we have found it rise to 43.083; 3. In diabetes, in which the increase of solid matters is enormous.

This increase of the solid constituents imparts different characters to the urine, according to the amount of water in which they are dissolved. Thus, when the increase is the result of a substantial, highly nitrogenized diet, the quantity of water remains unchanged, and the urine is loaded, dark-coloured, and of high specific gravity. Where, however, this increase follows the introduction into the system, of an unusual amount of water, the contrary takes place, and the urine is pale, limpid, and of low specific gravity.

Decrease of the Solid Matters.—This is of more frequent occurrence than their increase. It takes place under the influence of two morbid conditions, diametrically opposed to one another. 1. A. Fever, acute inflammation, functional derangement of moderate severity, the exacerbations which occur in diseases of the lungs and heart, diseases of the liver, etc., diminish the solid constituents of the urine. According to the experience of M. Becquerel, this diminution varies from 28.672 to 11.284, the mean being 24.148.

This decrease of the solid constituents, imparts different qualities to the urine, according to the quantity of water by which they are held in solution. It is usual to observe a still greater decrease on the part of the water; and the urine therefore, in these cases, is frequently of a very dark colour, of high specific gravity, strongly acid, and deposits a sediment. If the proportion of water, however, be not sensibly lessened, the urine is less dense, paler, and faintly acid.

B. Under the influence of similar circumstances, if there be, in addition, any cause of debility, exhaustion, or anæmia, the aggregate of the solid matters of the urine diminishes still further. Thus, twelve experiments, made by M. Becquerel, gave a mean of 14.150. The highest being 20.519, and the lowest 5.144. This diminished proportion of solids may be dissolved in very different quantities of water.

2. Under the influence of debilitating circumstances, irrespective of fever, inflammation, or functional derangement, the aggregate of the solid constituents of the urine is diminished. This occurs in chlorosis, in anæmia, and in the debility resulting from various causes, such as loss of blood, profuse suppuration, etc. etc.

Twenty-seven experiments made upon cases included in the above category, gave a mean of 21.069; the maximum being 31.498 and the minimum 9.832 (Becquerel).

This diminished proportion of solid matters, is generally contained in a quantity of water which differs but little from the standard of health. The urine therefore is paler, less acid, and of lower specific gravity, etc. Lastly, the aggregate of solid matters held in solution, not unfrequently remains unchanged in disease.

C. THE UREA.

The urea is one of the most important of the constituent elements of the urine. To isolate and weigh it, several procedures may be adopted. One of these, recommended by Berzelius, affords urea in a state of purity; but it is too tedious, and requires too large a quantity of urine. It is, moreover, very complicated and of difficult execution. Another, due to M. Lecanu, is more simple and affords sufficiently accurate results: it is that which we have adopted in our numerous analyses, and is as follows:

The urine is first evaporated to the consistence of a syrup by a gentle heat. This syrup is then treated with alcohol of 36°. A deposit is formed, and the urea, colouring matter, lactic acid, and a portion of the extractive matters are dissolved by the alcohol. The precipitate, composed of alkaline and earthy salts, uric acid and urates, is now filtered and washed with alcohol, in order to remove any traces of urea that may have been left behind; the alcoholic solutions are then mixed and evaporated, and as soon as they have attained the consistence of syrup, the residuum is treated with an equal weight of pure nitric acid, and left to crystallize. A crystalline mass is thus formed, which retains in its meshes the mother water, holding in solution the lactic acid and extractive matters. The nitrate of urea is now squeezed in a fine muslin bag, and the brownish coloured water thus extracted is again treated with nitric acid, in order to remove all traces of urea.

The nitrate of urea thus obtained is not quite pure; it requires to be introduced into a linen bag, treated with iced water, again pressed between linen or blotting paper, and then dried in a stove at a gentle heat.

The residue is pure nitrate of urea. It is dried, weighed, and the amount of urea deduced, from what is known relative to the composition, by weight, of nitrate of urea, viz., urea, 48.988; nitric acid, 43.781; water, 7.281 (Regnault).

We here simply point out the process employed, without reference to the numerous precautions which must be taken in order to obtain accurate results; these we have treated of in another work (*Séméiotique des urines*, p. 33).

Mean amount of urea in health.

	Mean density of the urine.	Amount of urea secreted in twenty-four hours.	Umount of urea in 1000 grammes of urine.
Males . .	1018.900	17.537	13.838
Females . .	1015.120	15.582	10.366
Mean of both .	1017.010	16.555	12.102

To sum up, then, we may admit that the quantity of urea contained in 1000 grammes of urine may vary from 10 to 14 grammes,* and the quantity secreted in twenty-four hours from 15 to 18 grammes.†

The proportions given by M. Lecanu differ but little from those of Becquerel. The first of these authors limited his researches respecting the urea, chiefly to the ordinary conditions of health ; the latter extended his investigations to a consideration of the urine, in both its physiological and pathological states. From their combined analyses we may draw the following conclusions.

a. The amount of urea contained in urine passed during twenty-four hours, remains sometimes unchanged, whatever be the quantity of water holding the solid matters in solution; whether it be diminished, and the urine turbid and high coloured, or increased, with pale and limpid urine.

b. The proportion of urea rarely undergoes an increase; this is quite an exceptional occurrence.

c. In the majority of diseases capable of modifying the urinary secretion, the healthy proportion of urea secreted during the space of twenty-four hours, is for the most part diminished. We may divide the cases in which decrease of the urea takes place, into five classes.

First Class.—In this, the urine is dark coloured, of high specific gravity, very acid, and generally scanty.

Causes.—Fever, inflammation, general functional derangement, diseases of the liver.

Mean density of the urine, 1021.914; mean proportion of water, 616.495 ; do. of urea, 9.

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* From 150 to 210 grains.

† From 225 to 270 grains.

Second Class.—Urine pale, transparent, of moderate specific gravity; scarcely, if at all, diminished in quantity.

Causes.—Anæmia, chlorosis, debility from certain discharges.

Mean density, 1011.837; mean proportion of water, 1161.390; do. of urea, 7.030.

Third Class.—Urine somewhat dark coloured and loaded, diminished in quantity, but not of high specific gravity.

Causes.—Anæmia, chlorosis, debility with feverish symptoms, inflammation, or functional derangement.

Mean density, 1014.880; mean proportion of water, 594.051; do. of urea, 4,918.

Fourth Class.—Urine similar to the preceding, but containing a larger proportion of water.

Causes.—They are similar to those of the first class, with the exception of there being a larger quantity of water in the urine, for which we are unable to account.

Mean density, 1010.500; mean proportion of water, 1285,230; do. of urea, 8.919.

Fifth Class.—Urine natural, in spite of disease.

Causes.—Various indispositions, slight diseases, neuroses, etc.

Mean density, 1017.747; mean proportion of water, 949.316; do. of urea, 12.351.

CHANGES IN THE QUALITY OF THE UREA.

Whenever the urine becomes alkaline, and this is by no means rare, the change results from the decomposition of the urea. This may readily be explained.

An examination of the atomic formula of urea, shows this compound to be equivalent to cyanate of ammonia, or to anhydrous carbonate of ammonia, from which the elements of two atoms of water have been withdrawn.

When heated to about 300° centigrade, the urea is converted into ammonia, and into a powder, which is nothing more than cyanic acid; by distilling it, we obtain anhydrous cyanic acid and a small quantity of urea.

Urea, by the absorption of the elements of two atoms of water, becomes transformed into carbonate of ammonia. The facility with which such transformation takes place, depends much upon the contact of the urea with animal matters, as occurs in the urine. From the moment this fluid is secreted, but more particularly as soon as it has left the bladder, the decomposition of urea commences, and continues, with greater or less rapidity, according to circumstances. The warm, dry weather of summer tends to favour it. We shall presently see, that pus and mucus do so likewise, in a remarkable degree.

Decomposition of the urea having begun, there follows the production of carbonate of ammonia, which renders the urine, first neutral, and then alkaline. Here commence the varied phenomena which characterize the spontaneous decomposition of this liquid: sub-carbonate of lime is formed and precipitated; the phosphate of lime, being no longer held in solution by acid, is likewise deposited; the ammonia, losing its carbonic acid, which combines with the lime, itself combines with the acid phosphate of magnesia, and converts it into a neutral or bibasic ammoniaco-magnesian phosphate, which crystallizes. At the same time, the colouring matter of the urine becomes paler and is partially destroyed. We must here remark, that the decomposition of the urea begins while the urine is still acid, although there may be nothing to indicate that such a process is actually going on. Under certain circumstances, however, the urine, while retaining its acidity, presents a peculiar appearance, which may have led certain observers into error, by inducing them to believe in the presence of albumen.

If we heat a few specimens of urine taken promiscuously, and raise the temperature to the boiling point, we shall find, probably, that some of them become opaque, turbid, and give rise to a more or less abundant precipitate. This phenomenon was usually considered indicative of the presence of albumen, as this was said to be the only principle in acid urine, coagulable by heat. Such, however, is not the case. This whitish deposit is entirely composed of subcarbonate of lime, and sometimes of magnesia, from which the excess of carbonic acid, by which alone they were held in solution, has been removed by heat. As a proof of this, if such urine be treated with an acid, the lime and the magnesia are dissolved and bubbles of carbonic acid escape.

We must here say a few words respecting the important part which urea performs in the organism generally, inasmuch as certain diathetic conditions are now explained, by reference to special modifications which this constituent of the urine is said to undergo. Urea is one of the residuary matters of the interstitial nutrition of the tissues. In a word, it is a product of the decomposition of those tissues, which no longer constitute a part of the system, and are hence eliminated in this form. The secretion from the kidneys is therefore one of the most important phenomena of the economy, a phenomenon, the due accomplishment of which, cannot be interrupted or prevented, without serious inconvenience, and even danger.

Before the residue of the tissues can leave the system in given quantity, in the form of urea, they must have been completely burnt by the oxygen circulating in the blood. In the great majority of cases this actually occurs. But it is not always so, for under certain circumstances, of which we shall speak hereafter, the oxygen is not sufficient to consume the tissues which have ceased to constitute a portion of the organism, or, what comes to the same thing, it is employed for other purposes. Moreover, the supply of oxygen remaining unchanged, there may be an excess of tissue requiring consumption. In all these cases, the final result is the same. Instead of urea, a partially oxidised product is formed, chiefly uric acid; hence it is, that we meet with that condition of the system in general, to which the term *uric acid diathesis* has been applied. We shall revert to this subject hereafter.

D. OF THE URIC ACID AND ACID URATES OF AMMONIA, POTASH, SODA, LIME, AND MAGNESIA.

The uric acid, although existing in small quantity, is yet one of the most important elements of the urine, and undergoes very considerable variations in disease.

Uric acid, except in some rare cases, does not exist in a free state in the urine. The deposits so frequently met with in this liquid, being composed, according to Prout, Rayer, and Donné, of acid urate of ammonia, intermixed with a small quantity of alkaline acid or earthy urates. According to MM. Quevenne and Becquerel, they are composed of uric acid rendered amorphous by being mixed or combined with a certain amount of animal matter (colouring and extractive matters).

The procedure recommended by M. Lecanu for removing uric acid from the urine is excellent. It is obtained in the process adopted for the removal of the urea. We have said, that to extract this latter principle, the urine must be evaporated to the consistence of a syrup, and then treated with alcohol; a deposit is thus formed, together with an insoluble precipitate, composed of the alkaline and earthy salts of the urine, plus the uric acid and a small quantity of colouring and animal matters. It is from this precipitate, insoluble in alcohol, that uric acid is obtained. Having been first washed with this liquid, in order to remove all traces of urea, it is then left to drain, and is afterwards treated with distilled water slightly acidulated with hydrochloric acid. This acid immediately dissolves all the alkaline and earthy salts, together with a small quantity of extractive animal matter by which they were held together. This solution takes place with the greater facility, from their being in the form of hydrates. Moreover, hydrochloric acid dissolves the urates, should there be any; this is, however, the exception. The liquid is again filtered, and we obtain, as residuum, a greyish white powder, which is almost pure uric acid, occasionally, however, combined with a small quantity of animal matter. This grey powder, after having been slowly dried at a gentle heat, may with ease be weighed.

The addition of hydrochloric acid, should be made at a low temperature, otherwise a certain amount of uric acid would be dissolved, and would no longer crystallize on cooling.

The following table shews the healthy proportion of uric acid contained in the urine:

	Specific gravity.	Uric acid contained in 1000 grammes of urine.	Uric acid secreted in 24 hours.
Males . .	1018.900	0.391	0.495
Females . .	1015.170	0.496	0.557
Mean of both .	1017.010	0.398	0.526

There is reason to believe, that in 1000 parts of healthy urine, the mean proportion of uric acid may vary from 0.3 to 0.5, and that the amount secreted in the space of twenty-four hours may likewise vary from 0.4 to 0.6.

Sect. III.—Of the Changes which the Uric Acid may undergo in Disease.

These changes may be classed under three distinct heads:

1. *Increased proportion of uric acid secreted in the twenty-four hours.*

The uric acid increases in quantity:

a. Under certain physiological circumstances, such, for instance, as a fit of anger, a sudden emotion, a full meal, dietetic excesses, etc.;

b. In fever, whatever may be its cause, whether functional or organic;

c. In acute functional derangement, from whatever cause: such as the fits of dyspnœa occurring in pulmonary emphysema or organic disease of the heart, acute pain, convulsions, delirium, etc.;

d. In diseases of the liver, more especially acute and chronic hepatitis, cancer, and cirrhosis.

In these four classes of cases taken collectively, we have found the mean density of the urine to be, 1021.654; the proportion of water, 653.454; that of uric acid, 1.041.

We see from this, that the increased proportion of uric acid is generally held in solution by a smaller quantity of water than usual, the consequence of which, is the formation of sedimentary deposits composed entirely of uric acid, or rather of urates. These deposits, when examined under the microscope, present the appearance of amorphous granules, and not of uric acid crystals, shewing that they are not formed of pure uric acid, but of urates, or uric acid in combination with a small quantity of animal matter.

There is one important pathological condition in which the uric acid is increased in quantity, and deposited in the crystalline form, viz., in the uric acid diathesis. The urine being the principal medium of elimination, this constituent is excreted in the form of crystals. This is especially the case in gout and gravel.

2. *The healthy proportion of uric acid remains unchanged, or nearly so.*

The circumstances under which this condition of the urine occurs, are analogous to those of the preceding category. The individuals in whom it is met with, may be the subjects of fever, of functional derangement, of diseases of the heart and liver, etc.; they differ, however, from those of the former class, in that, from the nature of their disease, the discharges from which they may have suffered, and the therapeutic measures to which they may have been subjected, they are for the most part greatly debilitated.

The following mean proportions are deduced from a given number of cases of this kind:

Specific gravity, 1016.437; proportion of water, 590.450; ditto of uric acid, 0.559.

In these cases it usually happens, that the healthy proportion of uric acid being dissolved in a smaller quantity of water than natural, it is deposited, and forms sediments, as in the former class of cases.

3. *The quantity of uric acid is diminished.*

Two causes contribute mainly to this result: 1. Chlorosis; and 2. Anæmia, whatever may have been its origin; provided there be no febrile symptoms or acute constitutional disturbance.

The mean proportion of uric acid in such cases is 0.218; that of the water, 1080.901; while the specific gravity of the urine is 1011.855. This latter is generally pale, limpid, and free from deposits.

Such are the principal modifications of the uric acid, in point of quantity. To the practitioner, however, this is not the most important consideration. The subject of interest to him, is the ratio between the quantity of uric acid and that of the water; or, in other words, the relative amount of uric acid contained in 1000 parts of urine.

Viewed in this light, the examination of the urine is of great importance; it comprises almost the entire investigation of the deposits.

Bearing in mind then, that the mean amount of uric acid in 1000 grammes of urine is 0.400, and that it may increase to 0.600, 0.700, 0.800, 1.000, 2.000, and even 3.000 per 1000, we shall proceed to examine the manner in which this increase may take place.

A. INCREASE OF THE URIC ACID, RELATIVE TO THE AMOUNT OF WATER.

The three following cases may present themselves: 1. The urine remains transparent; 2. A deposit is formed on the addition of a small quantity of nitric acid; 3. This deposit or sediment may form spontaneously.

Certain characteristics are common to each of these cases: *a.* The urine is strongly acid; *b.* It is high coloured; *c.* Its specific gravity is higher than in health.

FIRST VARIETY.—*The Urine remains transparent.*—It is, moreover, as we have before stated, dark coloured, very acid, and of high specific gravity. Occasionally it remains so; at other times, however, a deposit is formed. This not unfrequently happens in winter. These cases do not coincide with the greatest increase of the uric acid.

SECOND VARIETY.—*The Urine, at first transparent, of high specific gravity, highly coloured, and strongly acid, deposits a sediment on the addition of a few drops of nitric acid.* This sediment is composed of uric acid, in combination with a small quantity of animal matter. It is consequently uncrystallized.

a. Of the cause of this deposit.—The deposit is not merely due to an excess of uric acid, as this alone will not suffice for its production. There is probably some unknown molecular action, perhaps of an electrical nature, which determines the deposition in question. Possibly, also, the nitric acid may form a special compound with a small proportion of the uric acid; and when once this action has commenced, may not the excess of the compound, thus formed, follow the first particles, already deposited in virtue of the unknown physical process which we have presupposed?

b. Of the manner in which the deposit is formed.—This may be twofold: either the urine becomes turbid and the sediment diffused throughout; or the particles of uric acid collect in the centre and form an opaque cloud, or suspended sediment, so to speak. This singular property is due to the small amount of the deposit, to the viscidity and consistence of the fluid, and to the form of the vessel.

c. Of the chemico-physical properties of the deposit. It is soluble in an excess of nitric acid. It is likewise soluble when boiled in the urine in which it is deposited. Its colour varies considerably, according to the amount of colouring matter contained in the urine, and may present different shades between white and brick red. Microscopic examination shews it to be composed of an exceedingly fine amorphous powder, formed of irregular opaque blackish granules, the diameter of which cannot be accurately ascertained, but may be estimated at about the $\frac{1}{500}$th of a millimètre.

Such sediments have been occasionally mistaken for albumen. They may be distinguished, however, by being dissolved by heat, or by an excess of acid.

THIRD VARIETY.—*The uric acid is in excess, and is spontaneously precipitated, either on the urine becoming cool, or after the lapse of a few hours.*—Urine presenting this peculiarity is (before the formation of the deposit) highly coloured, strongly acid, of high specific gravity, and frequently throws down a precipitate, upon the addition of nitric acid.

The formation of this precipitate may be explained: 1. By the excess of uric acid; and 2. By the reduction of temperature which the urine experiences on leaving the body. For this latter reason, the deposit forms with greater facility in winter.

The urine is occasionally voided in a sedimentary condition. This indicates the presence of a larger amount of uric acid, than when the precipitate forms at a subsequent period. In other cases, however, it forms immediately after the urine has left the bladder; and sometimes not until several hours have elapsed.

The following experimental results were obtained by M. Becquerel:

Of 443 specimens of urine, set aside from six in the morning to six in the evening, 102 deposited a sediment. Of these last, 71 had deposited the uric acid at nine in the morning; while the remaining 31 did so only after the lapse of several hours.

The deposit does not always form in the same manner. Sometimes the entire urine becomes turbid, but subsequently regains its transparency by the subsidence of the uric acid to the bottom of the vessel.

In other cases the sediment remains suspended in the urine. This phenomenon, the cause of which remained for some time undiscovered, is due to the presence of a layer of mucus at the lower part of the vessel, which prevents the deposit from settling to the bottom.

Of the chemico-physical properties of these sediments.—They are somewhat remarkable, and may be summed up thus. Deposits of uric acid are dissolved by heat, and by an excess of nitric acid. Their colour depends upon the amount of colouring matter with which the uric acid is combined. If it be entirely absent, as not unfrequently happens in the turbid urine of chlorotic females, the deposit is white, greyish white, or yellowish white. If, on the other hand, there exist a certain amount of colouring matter, the deposit has a yellow or reddish colour. Lastly, if the colouring matter be in excess, the deposit resembles brickdust. It is to this latter that the term *rosacic acid* has been applied. This pretended acid, however, is nothing more than uric acid in combination with a great excess of colouring matter.

Microscopic examination shews these deposits to be composed of a multitude of fine blackish granules, variously grouped, so as frequently to assume the strangest forms. At times they present the appearance of black globules, owing to the approximation and agglomeration of the granules.

B. OF THE PROPERTIES OF THE URINE, WHICH INDICATE A DIMINISHED PROPORTION OF URIC ACID.

Urine containing but a small proportion of uric acid, is usually pale, feebly acid, and of low specific gravity. This latter property is owing to the fact, that when the uric acid is decreased in quantity, the other chemical constituents of the urine almost always undergo a similar change.

C. OF CHANGES IN THE QUALITY OF THE URIC ACID.

We do not here speak of the different conditions in which uric acid may exist in the urine, whether in the form of crystals, or in combination with animal or extractive matters; or with ammonia, potash, soda, and lime; as these compounds are found, for the most part, in the sediments to which the name of *uric acid sediments* has been applied in general.

We shall merely, therefore, point out certain properties of this acid with which it is necessary to be acquainted; these are as follows:

1. Crystallized uric acid is insoluble even in hot water.
2. Cold hydrochloric acid has no apparent effect upon it.
3. Nitric acid, if concentrated, dissolves it.
4. When exposed in a retort to the action of heat, we find, as the products of distillation, urea, cyanuric acid, hydrocyanic acid, and ammonia.
5. When exposed to the oxidising influence of peroxide of lead, it gives rise, by absorbing an atom of oxygen, to oxalic acid, urea, and allantoin (allantoic acid of Lassaigne; amniotic

acid of Vauquelin). This transformation may probably take place in the system under certain circumstances, and it is important to bear this in mind.

6. The action of strong nitric acid upon uric acid gives rise to two substances, which, when combined with ammonia, form what is termed purpurate of ammonia.

SECT. IV.—Of the Inorganic Matters held in Solution in the Tissues, and Undecomposed at a Red Heat.

These are as follows:

Sulphate of potash,
Sulphate of soda,
Chloride of sodium,
Phosphate of soda,
Phosphate of lime,
Phosphate of magnesia,
Silica (according to Berzelius),
Phosphoric acid in combination with ammonia,
Soda in combination with lactic acid.

Or we may represent them thus:

$$\left.\begin{array}{l}\text{Sulphuric acid,}\\ \text{Phosphoric acid,}\end{array}\right\}\ \begin{array}{c}\text{In combination}\\ \text{with . .}\end{array}\ \left\{\begin{array}{l}\text{Potash,}\\ \text{Soda,}\\ \text{Lime,}\\ \text{Magnesia,}\end{array}\right.$$

Chlorine, combined with the radicals of the preceding oxides.
A trace of silica.

To obtain these saline matters, whether separately or in combination, two methods of procedure may be had recourse to, the results of which are identical; the first, however, is more tedious, costly, and delicate than the second.

First Process.—The urine, having been previously weighed, is to be evaporated in a porcelain capsule; when reduced to the consistence of a syrup, the evaporation is to be continued to dryness in a porcelain crucible, which, having been covered with a lid of similar material, is to be heated to a white heat.

At this temperature all organic matters are destroyed, the hydrochlorate of ammonia is volatilized, and nothing remains in the crucible but a white granulated crystalline mass, composed of the above-mentioned salts.

This process affords accurate results, but is tedious, costly, and requires much care.

Second Process.—We prefer this, which is due to M. Lecanu; it is accurate, simple, easily accomplished, and is thus described by the author:

"Owing to the conversion of urea into nitrate of ammonia under the influence of heat and nitric acid, and to the property which the nitrate of ammonia possesses, of readily consuming the combustible elements of the organic matters, the operation becomes almost instantaneous. To the syrupy extract resulting from the evaporation of 500 parts of urine, 20 to 25 parts of nitric acid are added. The application of heat is continued until the mass assumes such a consistence, as shall admit of its becoming solid when cold. As soon as this takes place, it is thrown, in small pieces at a time, into a red hot platinum crucible. A smart deflagration immediately ensues, the organic matters are completely destroyed, while the fixed salts constitute the residuum, and assume the aspect of a pure white mass. After having been maintained in a state of fusion for a few moments, their analysis may at once be proceeded with."

The following table, shewing the mean composition of the saline ingredients of the urine, is the result of our own analyses:

	Amount of salts in 1000 parts of saline matter.	Amount of salts in 1000 parts of urine.	Amount of salts in the urine of 24 hours.
Sulphuric acid	12.36	0.855	1.123
Chlorine	7.25	0.502	0.659
Phosphoric acid	4.59	0.317	0.417
Potash	18.80	1.300	1.708
Soda, lime, and magnesia	57.00	3.944	5.181
	100.00	6.919	9.089

From the numerous analyses hitherto made, we may conclude that the inorganic salts vary in quantity from eight to ten grammes in the urine of twenty-four hours, and from five to eight grammes in 1000 grammes of that fluid.

In certain pathological states of the body, the sum total of this saline residuum, or of its component parts, may vary very considerably. The following conclusions have been arrived at on this head by M. Becquerel, in his *Séméiotique des urines.*

The variations in quantity of the inorganic salts of the urine, are similar to those of the urea, but less marked, and bear less resemblance to each other.

With certain exceptions, already mentioned (cases in which the urine differs but little from that of health, and in which a large amount of water has been introduced into the system), an actual decrease in quantity, of the inorganic salts of the urine, is the rule; but the exact amount of this decrease is so liable to variation, that it is impossible to calculate the average, inasmuch as it may oscillate between one and eight.

Should there be an absolute decrease in the proportion of salts, together with a small quantity of water, these salts, although less abundant than in health, become concentrated in the diminished volume of water, and may thus appear to exceed the healthy standard. On the other hand, an excess of the salts, if diluted with a large quantity of water, may appear to afford a smaller per centage than in health.

The specific gravity of the urine is nearly proportionate to the inorganic salts contained therein. At least, this is the only guide that we can suggest for obtaining an approximate notion, relative to the amount of salts contained in the urine about to be submitted to examination.

SECT. V.—Of the Organic Matters held in Solution by the Urine.

These are:

1. Free lactic acid, probably combined with a small proportion of urea as lactate of urea. This has been ascertained by the researches of MM. Cap and Henry. It is, however, excedingly difficult to analyze the compounds of lactic acid;
2. Lactate of ammonia;

3. Lactate of soda;

4. Hydrochlorate of ammonia. When carbonate of ammonia is present, it arises from the decomposition of a small quantity of urea;

5. Colouring matter;

6. Extractive matters properly so called, and in which may be reckoned the *extractum carnis* of Berzelius.

The mean physiological proportion of organic matters is 10.696 in the urine of twenty-four hours, and 8.647 in 1000 grammes of that fluid. The variations, however, may be from eight to twelve grammes in the former case, and from seven to ten in the latter.

In his work, entitled *De la Séméiotique des urines*, M. Becquerel has arrived at the following conclusions, respecting the pathological changes to which the organic matters of the urine are liable:

In certain acute febrile diseases with great functional derangement, and in diseases of the liver, we may meet with one of the three following conditions: *a.* An increase, generally trifling, of the organic matters; *b.* A healthy proportion of the same (within the limits previously mentioned); and *c.* A slight decrease in the quantity of these substances.

These three conditions, differing little from that of health, but coinciding with a diminished amount of water, always appear to indicate a relative increase in point of quantity. The amount of urine being represented by 1000, concentration takes place, in a similar sense to what we have seen to occur in the case of the urea, uric acid, and inorganic salts.

In diseases where the proportion of water differs but little from that of health, the relative proportions of the organic matters (the urine being represented by 1000) remain within the ordinary physiological limits.

In diseases characterized by anæmia, debility, and exhaustion, from whatever cause they may arise, there is both a relative and absolute decrease in the quantity of the organic matters; the decrease, however, is much less considerable than that of the other chemical constituents of the urine.

SECT. VI.—Of the Changes which the Organic Matters of the Urine may undergo separately.

Colouring Matters.—It is exceedingly difficult to determine the exact nature of the colouring matter of the urine, owing to its extreme solubility in liquids generally, and to the impossibility of separating it from the so-called extractive matters. It was ascertained by Bellini, and subsequently by Boerhaave, that, with a specimen of the darkest coloured urine, every intermediate shade found in nature, might be imitated, simply by the addition of water in various quantities. To this proposition we give our full assent.

Is the colouring matter of the urine due, as Prout believes, to a species of urinary resin? or, according to Berzelius, to an extractive colouring matter, of a pungent aromatic taste, and soluble in alcohol? Is this colouring matter of a similar nature to the yellow colouring matter of the bile (bilifulvin)? or to the yellow colouring of the blood (the hæmaphein)? These are questions to which, as yet, no satisfactory answer has been given.

When deposits form in acid urine, we frequently observe the uric acid, while being precipitated, to carry along with it a certain amount of colouring matter, with which it is combined; and the proportion of which, determines the intensity of colour of the deposit.

In some cases the deposit is of a bright red colour. This has been attributed by Dr. Prout to the presence of a particular kind of acid, which he terms *rosacic acid.* According to M. Becquerel, however, this red appearance of the sediments of the urine, is simply owing to a large excess of colouring matter being precipitated along with the uric acid.

This is proved by the following experiments.

A certain quantity of this red deposit is collected from the urine of several individuals, affected with diseases of the liver, for example. It is washed with cold distilled water, in order to remove all traces of urine. This operation is performed on a filter. The deposit is then treated with boiling alcohol. The alcohol dissolves the colouring matter, together with a small quantity of uric acid, which, however, is subsequently deposited on cooling, in the form of a grey insoluble powder. It is often necessary to repeat the process several times, owing to the difficulty of removing all the colouring matter.

This colouring matter, when in solution, is not red, but presents, on the contrary, a tint exactly similar to that of ordinary urine, and the gradual addition of water enables us to imitate all the different phases of colour which that fluid may present.

In health, the amount of colouring matter is constantly liable to slight variations within certain limits: at one time it is darker, at another paler. The urine of the human female contains less colouring matter than that of the male.

Increase of the colouring matters.—This is usually observed in connexion with a decrease of the water and an increase of the uric acid, and it may be laid down as a general rule, that in such cases there is a coincidence of the three following phenomena.

a. Marked decrease of the water.

b. Absolute and relative increase of the quantity of uric acid.

c. Absolute and relative increase of the colouring matter.

Diminution of the healthy proportion of colouring matter.—This is not an uncommon occurrence, and can only be judged of by the colour of the urine.

It sometimes, though rarely, coincides with a decrease in the quantity of the water; for the most part, however, the urine becomes paler and paler in proportion to the increase of its watery element.

It may occasionally occur, likewise, when the proportion of water scarcely exceeds the limits of health; this happens in anæmic individuals, in convalescents, and in those who are much debilitated.

Changes in the nature of the colouring matter.—The different coloured kinds of urine constantly met with (without intermixture of pus, blood, or bile), are due, in all probability, to the presence of the colouring matter in different proportions, and to its combination with variable quantities of the other chemical constituents of the urine.

Lactic Acid.—This constitutes the great proportion of the indeterminate organic matters of the urine. It is this which holds in solution the phosphate of lime and ammoniaco-magnesian phosphate.

It would appear probable, from the experiments of MM. Cap and Henry, that the lactic acid exists in the urine as lactate of urea. Lactate of soda is also met with in small quantity. It may be laid down as a general rule, that the amount of lactic acid is in direct ratio to the acidity of the urine; and that it is not unfrequently proportionate to the quantity of organic matters contained in that fluid. In fact, the urine is generally more acid in proportion as it is dark coloured, loaded with deposit, and of high specific gravity.

SECT. VII.—Of the Organic or Inorganic Matters accidentally met with in the Urine.

Of these, two kinds are met with.

The first comprises those substances which are the simple consequence of a spontaneous decomposition of the ordinary chemical constituents of the urine.

The second comprehends certain substances, having no analogy to those which are met with in health.

CLASS I.—*Newly formed matters existing in the urine and resulting from the spontaneous decomposition of its normal constituents.*

We must here include the products of the decomposition of the urine, together with the alkaline qualities which this fluid then assumes.

In the decomposition of the urine, there is one most important phenomenon to which all others are subservient, and to which, in fact, they may be attributed: viz., the conversion of urea into subcarbonate of ammonia, under the prolonged influence of water and of the presence of organic matters. It is the subcarbonate of ammonia, which, by its simultaneous action upon the different constituents of the urine, *i. e.*, the lactic acid, uric acid, inorganic salts, and organic matters, produces decomposition of each of these elementary principles, and engenders a variety of new combinations.

After giving a slight sketch of the general phenomena attending the spontaneous decomposition of urine, we shall proceed to speak of the various products to which it gives rise; bearing in mind this important fact, which simplifies greatly the explanation of these phenomena, viz., that they all are the consequences of the transformation of urea into carbonate of ammonia.

The spontaneous changes which take place in the urine when left to itself, are as follows. It becomes paler, acquires an ammoniacal odour, an alkaline reaction, and presents a white pellicle upon its surface; on the sides of the vessel are deposited small white crystals of ammoniaco-magnesian phosphate. By degrees it becomes sufficiently alkaline to effervesce upon the addition of an acid. By spontaneous evaporation it becomes concentrated, and deposits, at first, yellow cubic crystals of hydrochlorate of ammonia, then octahedral crystals of chloride of sodium, and lastly, phosphate of ammonia and soda. The carbonic acid of the carbonate of ammonia having yielded a portion of its base to the phosphates, enters into combination with a certain amount of lime and magnesia. To sum up, then, the newly formed products resulting from the decomposition of the urine are as follows:

a. Subcarbonates of lime and magnesia;
b. Neutral phosphates of lime;
c. Neutral ammoniaco-magnesian phosphate;
d. Bibasic ammoniaco-magnesian phosphate.

1. *Sub-carbonates of lime and magnesia.*—The carbonates do not exist naturally in the urine; their presence almost always indicates that the transformation of urea into carbonate of ammonia has already commenced.

In certain specimens of acid urine when raised to a temperature of 100°, centigrade measurement, we observe the formation of a more or less abundant white precipitate, which has been not unfrequently mistaken for albumen. This is not the case, however; it is merely sub-carbonate of lime, which being dissolved in the urine by an excess of carbonic acid, is precipitated when this latter is drawn off by heat.

This may be proved by microscopic examination, but the most convincing evidence is derived from the addition of a few drops of nitric acid to the urine, when the precipitate is at once dissolved with brisk effervescence, indicating the liberation of carbonic acid. This important fact has not, we believe, been hitherto pointed out, at least in the case of acid urine.

The possibility of mistaking this deposit for albumen, explains the importance which we attach to it.

We are fully acquainted, however, with the existence of carbonates in neutral or alkaline urine, whether transparent or opaque: when transparent, heat, by driving off the excess of carbonic acid, allows the deposition of the carbonate of lime, which dissolves with effervescence, upon the addition of a small quantity of nitric acid. In alkaline urine containing sediments, a portion of these latter dissolve with brisk effervescence when nitric acid is added: this depends on the existence, in the deposit, of sub-carbonate of lime and magnesia. The presence of these sub-carbonates in neutral or alkaline urine may be readily understood, if we bear in mind the fact, that these neutral or alkaline properties are entirely due to the conversion of urea into carbonate of ammonia, which is subsequently decomposed, the alkali combining with the biphosphate of ammonia and magnesia, and the carbonic acid, with the lime and magnesia. When examined under the microscope, these salts of lime and magnesia present the appearance of amorphous dust, composed of a multitude of small rounded granules.

Neutral phosphate of lime.—This constitutes a portion of the deposit found in alkaline urine. We have nothing particular to say respecting it.

Neutral and bibasic ammoniaco-magnesian phosphates.—If acid urine be left to itself, and we observe what takes place after it has become decomposed, the following phenomena present themselves.

The urea being gradually decomposed and converted into carbonate of ammonia, several ulterior decompositions ensue, resulting from the reaction of this compound upon the other salts.

The following is a remarkable instance of this kind :

The lime and magnesia existing in the urine in the form of acid phosphates, the carbonate of ammonia yields its alkali to the excess of phosphoric acid, and there results a neutral phosphate of lime which is precipitated, and phosphate of ammonia which combines with the phosphate of magnesia to form a double phosphate of ammonia, the second of which contains the largest proportion of ammonia.

The first, or neutral ammoniaco-magnesian phosphate, crystallizes in fine rectangular prisms, clearly discernible under the microscope.

On allowing a longer time to elapse, or on adding, for example, an excess of ammonia to acid urine, this latter becoming thus charged with a larger proportion of carbonate of ammonia, causes the neutral ammoniaco-magnesian phosphate to pass into the state of bibasic phosphate, which crystallizes in the form of foliacious laminæ, visible under the microscope.

The above changes in the urine, by which it is rendered both alkaline and, at the same time, capable of giving rise to the various combinations previously enumerated, may be said to have their type in the spontaneous changes which occur in urine when left to itself. They may be noticed in various affections, which we shall successively pass in review when treating of the urine in disease.

CLASS II.—*Accidental matters found in the urine, and which cannot be regarded as due to a spontaneous change on the part of its normal chemical constituents.*

Mucus.—The urine of the most healthy individual invariably contains a small quantity of mucus. On allowing urine to stand for a short time, and especially if it be artificially cooled, this mucus is seen to condense in the form of a light cloud, which sometimes remains suspended in the fluid, and at others, slowly subsides to the bottom of the vessel. A microscopic examination of this sediment demonstrates the presence of a certain number of epithelial scales, but rarely of globules.

Muco-pus.—In other cases, the sediment or cloud is more copious, more opaque, and may occasionally render all the urine contained in the vessel, turbid. Microscopic examination shews it to be composed of healthy mucus, mingled with a greater or less number of pus globules; mucus shreds, moreover, are almost always discerned. If urine of this kind be filtered, it becomes clear and limpid; the presence of albumen cannot be detected; while the residue left upon the filter affords no sensible traces of fatty matter.

It is to this substance, when found in the urine, that the term muco-pus may be applied. It is met with under the following circumstances. In the chronic urethral discharges of the male; in acute and chronic vaginitis in the female; in catarrhal inflammation of the cervix uteri and of the mucous membrane lining its cavity; in simple leucorrhœa, and in acute and chronic cystitis, as occurring in either sex, without ulceration of the mucous membrane of the bladder.

Pus.—Whenever pus is mingled with the urine, it imparts to it the following qualities: the urine is turbid, semi-opaque, or, rather, opaline. When left to itself, we, ere long, notice at the bottom of the vessel, a grumous deposit of a greyish white colour, while, at the same time, the supernatant fluid still remains somewhat turbid.

The presence of pus in the urine is the source of five different modifications of this product of the renal secretion.

1. It contains a large amount of *mucine*, an organic substance which, when mixed with a certain proportion of water, is the source of the viscidity of mucus, muco-pus, and pus.

2. The fatty matter of pus (partly composed of cholesterine) is introduced into the urine along with this morbid product, and if a portion of the fluid be evaporated, dried, and treated with alcohol and æther, its presence may readily be detected.

3. The serum of pus containing, as it always does, a certain amount of albumen, it is easy to conceive that when the former exists in the urine, it must impart to that fluid a small quan-

tity of this latter principle, which may be detected by filtering the purulent urine, collecting the fluid which passes through, and heating it to ebullition.

4. The presence of pus in the urine may likewise be detected by means of the microscope, numerous pus globules being discernible.

5. Urine containing a certain amount of pus is, in general, neutral or alkaline.

The conditions under which pus appears in the urine are tolerably numerous. They are as follows: in acute and chronic cystitis, with ulceration of the mucous membrane; in blenorrhagia, with chancres in the male urethra; in acute and chronic vaginitis, with chancre, in the female; in purulent nephritis (pyelitis), in the case of abscesses opening into the bladder, as in iliac abscess, pelvic abscess, etc., etc.

The presence of muco-pus or pus, almost inevitably causes rapid and premature decomposition of the chief organic constituents of the urine. It would appear as if these matters acted like a ferment capable of determining a rapid decomposition of the urea.

To this decomposition we shall not allude further, having done so previously.

Blood.—The urine may contain a certain quantity of blood, derived from the vesical mucous membrane, from the ureters, or from the kidneys themselves.

Should the quantity of blood be at all considerable, it may be detected by the naked eye. If, on the contrary, it be very small, the microscope alone can decide the question.

The blood appears to stand in no direct relation to any of the ordinary constituents of the urine. It is a foreign liquid, which becomes simply mixed up with the natural secretion of the kidneys; imparting to it, however, certain properties, which are as follows:

1. If abundant, it imparts its colour to the urine, as well as to the sediments with which it may be accidentally mingled.

2. It introduces a certain amount of albumen, owing to the presence of serum.

3. It renders the urine alkaline; to produce these two last results, the blood must be present in tolerable quantity.

4. Lastly, the fluid suspected of containing blood, when examined under the microscope, is seen to contain certain foreign bodies; these are the blood globules, which, however, rarely preserve their normal configuration, even in those cases where the contact has been but of short duration.

These globules assume an irregular form, with, apparently, torn, crenated edges.

At a later period the size of the globules diminishes, while their deformity increases, and they end either by disappearing entirely, or by leaving a few shapeless fragments. The blood globules, when treated under the microscope with ammonia or acetic acid, are completely dissolved.

The colouring matter of the blood, when mixed with urine, rapidly changes, and becomes dark and even black. Of this we have seen several instances, and we feel convinced, that the great majority of cases of black urine alluded to by the ancients, were of this description.

Albumen.—The presence of albumen in the urine has, of late years, given rise to numerous investigations, having for their object the elucidation of a morbid condition of recent discovery, and of which the pathognomonic symptom consists in the presence of this proximate principle in the urine. It is not, however, in *albuminuria** alone, that we meet with albumen in the renal secretion; its presence there in many other diseases has likewise been noticed, and to these we shall hereafter refer.

We do not purpose here to treat of that species of albuminous urine which is characteristic of Bright's disease; this will form the subject of a distinct section. We shall allude merely to the albumen occasionally found in the urine of individuals, who, whether healthy or not, present nevertheless no other symptoms of renal disorder.

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* *By some the disease is called albuminous nephritis, but we conceive the term Bright's disease to be its proper one, in justice to the discoverer.* (*Becquerel et Rodier.*)

This albumen may be due to the presence of either pus or blood: in such cases its origin may be detected by the means previously recommended for the recognition of these substances.

Albumen may be found in urine presenting every possible variety of colour.

In some cases we have noticed a dirty turbid appearance on the part of the fluid, and in others, a somewhat greenish livid tint. This latter was especially marked in the case of a male nurse of the Charité Hospital, whose urine contained a considerable quantity of albumen, although he himself had a sound constitution, was in good health, and had been free from disease during his whole lifetime.

In Bright's disease, the colour, consistence, and density of the urine afford certain valuable distinctive characteristics.

The albumen found in the urine of individuals who present no other indication of renal disease, bears no direct proportion or relation to the chemical constituents held in solution by that fluid.

Should it, however, be due to the presence of pus or blood, its quantity will be proportionate to that of these latter substances.

Undoubtedly the best and most certain test for the presence of albumen in the urine, although it presents certain drawbacks, is that afforded by heat. It is sufficient to heat the urine to ebullition; when it becomes turbid, and the albumen is precipitated. There are two circumstances in which this proceeding may fail to have the desired effect; fortunately, however, the precipitation of the albumen may be determined by the addition of a little nitric acid.

These circumstances are as follows:

1. In some cases of neutral or alkaline urine, the liquid remains clear, even after boiling; this is due to the solubility of albumen in alkaline solutions. A few drops of acid, however, will neutralize the alkali and favour the precipitation of the albumen.

2. In certain specimens of acid urine, containing but a small

quantity of albumen, ebullition will not at once cause its precipitation. We are ignorant of the cause of this phenomenon, which, however, is perhaps due to the albumen existing in the urine in some peculiar physical condition. Whether this be so or not, the addition of a drop or two of nitric acid immediately causes it to be precipitated.

Nitric acid is in itself a good test; but the results which it affords are not so certain and trustworthy; for the following reasons.

When a specimen of urine contains but a small quantity of albumen, the addition of nitric acid may at first cause its precipitation, but if an excess of acid be employed, the albumen may be re-dissolved. When heated to ebullition and concentrated, nitric acid, indeed, is capable of dissolving a very large amount of albumen.

In alkaline or neutral urine, nitric acid is the only test that should be employed to detect the presence of albumen.

When examined under the microscope, the albumen appears in the form of flocculi or clouds, of a slightly yellowish hue; this is due to its precipitation in combination with a little of the colouring matter of the bile. The form of these flakes is very irregular and uncertain, for their outline is often indistinct and even imperceptible; they are composed of a multitude of small organic particles, of irregular but roundish configuration, and of different sizes. It is not without design that we here employ the expression, *organic rounded particles*, inasmuch as the albumen has frequently been regarded as constituted by a large number of a peculiar species of globules, presenting invariably the same size and shape; microscopic examination, however, is far from confirming this view of the question.

These particles may readily be examined, when a drop of urine containing a small quantity of albumen is placed under the microscope, and a sufficient amount of nitric acid added to cause its precipitation.

It is thought by some, that albumen may be precipitated spontaneously from urine in which it is dissolved, at the moment of emission: all we can say is, that we have never observed anything of the kind, even in the most acid urine. In such cases the microscope has never demonstrated the slightest trace of albumen, and we conceive that the error may be attributed to the combinations which occur in sedimentary urine, between the mucus and uric acid; combinations which, as before stated, frequently assume a cloudy aspect. We have previously spoken of the methods by which these different appearances may be distinguished.

We have likewise warned the reader against an error that may be committed in boiling certain specimens of acid or alkaline urine: the slight precipitate which forms at a temperature of 100° centigrade, may be mistaken for albumen; it is, however, merely carbonate of lime: we shall not therefore return to the subject: contenting ourselves with stating, that it is absolutely necessary to treat a coagulum obtained by heat, especially if scanty, with a few drops of nitric acid, in order to determine whether it be of a calcareous nature; in which case the deposit will dissolve with effervescence and the disengagement of carbonic acid.

Excluding, for the moment, Bright's disease, albumen may be found in the urine under the following circumstances:

1. When pus or blood exist in the urine, but especially blood.

2. In acute febrile disease the albumen is usually very scanty, and very irregular in its appearance.

3. In diseases characterized by severe dyspnœa, which acts by determining sanguineous congestion of the kidneys, as well as of the other abdominal viscera.

4. In some diseases of the heart.

5. In many cases of dropsy, whatever be their cause.—Albumen is found in the urine whenever the serum effused in different parts of the body infiltrates the tissues of the kidney, so as to produce œdema of these organs. In such cases the urine almost invariably contains a certain amount of serosity, to which the presence of albumen is due.

6. In certain apyrexial diseases, indicated by functional derangement.

7. Lastly, in some cases the presence of albumen in the urine is inexplicable.

The following substances are much less frequently found in the urine, than those which we have just considered:

Sulphur.—It was thought by Prout, that free sulphur existed in the urine, but the researches of MM. Thenard and Berzelius do not appear to have confirmed this opinion.

Phosphorus was likewise supposed to exist in the urine in an uncombined state; this hypothesis was founded upon the fact, that certain specimens of urine become luminous in the dark. The subject itself requires renewed investigation; and there is reason to believe, that this rare and remarkable property on the part of the urine, may be due to some special condition assumed by many abnormal substances previous to undergoing decomposition.*

Iron.—Its presence has been noticed in some specimens of blue urine. We have ourselves constantly met with it in that of chlorotic individuals, to whom the preparations of iron had been administered. We shall return to this subject when speaking of the introduction of remedies and poisons into the urine.

Nitric Acid.—When treating of the colouring matter of the urine, we stated that Prout thought that the urine, in some instances, contained nitric acid in a particular state of combination. It was to the reaction of this acid upon lithic acid, that he attributed the formation of the purpuric acid which, in combination with ammonia, forms the red sediment of urine. Having already discussed this question, together with that of the rosacic acid, nothing further need be said respecting them.

Benzoic Acid.—According to Scheele, Prout, and Wurzer, benzoic acid exists in the urine. Berzelius, however, asserts the contrary.

Hippuric or Uro-benzoic Acid.—This acid is found more especially in the urine of herbivorous animals. Lehmann states that he has occasionally met with it in diabetic urine. M. Bouchardat has likewise found it in human urine, under certain morbid conditions.

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* Becquerel. *Traité de l'électricité et du magnetisme. Article, Phosphorescence.*

Butyric Acid.—According to Berzelius, a small quantity of this acid may be obtained from urine, by first mixing it with sulphuric acid, and then distilling the compound thus formed.

Fatty Matters.—Healthy urine affords slight traces of fatty matter, the presence of which, may be detected by means of sulphuric æther. In some cases, the amount of fatty matter is very considerable, appearing like a thin pellicle floating upon the surface of the urine. According to an analysis of M. Chevreuil, this would appear to be composed of oleine and stearine.

Oxalic Acid.—Owing to the great affinity of oxalic acid for lime, this acid is usually found in the urine in combination with the latter substance. Oxalate of lime is insoluble, and appears, according to Rayer, in the form of small granular crystals. M. Donné asserts that if sorrel be eaten at dinner, the urine passed in the evening will contain crystals of oxalate of lime, presenting the appearance of two pyramids united at their bases.

Xanthic Oxide.—It is so rarely met with, that but little is known of its history. Nitric acid turns it yellow.

Cystic Oxide or Cystine.—This substance, which enters into the composition of a certain number of calculi, is soluble in alkalies and in strong acids, but insoluble in water and alcohol. By precipitation from an ammoniacal solution, it has been obtained by MM. Rayer and Guibourt, in the form of six-sided transparent prisms, of various sizes.

Fibrin.—So great is the analogy between albumen and fibrin, that these two substances present, in every respect, identical properties. There exists between them, however, this trifing distinction, viz., that the oxygen contained in oxygenated water, is liberated by the latter, but not by the former. We can only therefore say of the fibrin, that which we have already said respecting the albumen. According to M. Denis, they are one and the same substance.

Chyle.—Chyle is occasionally met with in the urine, which in such cases presents the following distinctive characteristics. It contains, *a*, globules similar to those of the blood, soluble in acetic acid; *b*, a certain amount of albumen or fibrin; *c*, a fatty substance; this substance, from being disseminated throughout the fluid, produces that peculiar appearance resembling an emulsion, which characterizes this species of urine.

When left to itself, such urine presents on its surface an oily layer, which is due to the condensation of a portion of the fatty matter constituting the emulsion.

Oleaginous Fatty Matters.—Urine containing fatty matter, generally assumes, as we have already stated, the appearance of an emulsion; when allowed to stand for some time, this fatty matter condenses, and forms a layer upon the surface of the liquid. Sulphuric æther, by dissolving the fat, renders the urine transparent. A microscopic examination reveals the existence of a multitude of perfectly spherical fat globules of different sizes.

Saccharine Matters.—The presence of saccharine matter in the urine, is the pathognomonic sign of the disease termed diabetes; two varieties of it are recognized, the saccharine and the non-saccharine.

In the latter variety, the proportion of sugar is so small as to be inappreciable by the sense of taste. M. Bouchardat has shown, that the absence of saccharine flavour in such cases, is due to a special combination of the sugar with some of the other chemical constituents of the urine.

The presence of sugar greatly increases the specific gravity of the urine. It ferments spontaneously, and, as a consequence, produces a certain amount of alcohol, which is quickly converted into acetic acid.

This fermentation is rendered more rapid by the addition of yeast. The method employed for the removal of the sugar is very simple. The suspected urine is treated with acetate of lead, which possesses the property of precipitating the various matters held in solution, and more especially the animal matters. It is then filtered, and hydrosulphuric acid added, in order to precipitate any portions of lead that may have been dissolved; the liquid is again filtered, evaporated to the consistence of a syrup, and diabetic sugar is thus obtained. The addition of animal charcoal removes all impurities.

Its composition is identical with that of grape sugar; the fermentation of diabetic urine is due to the presence of a peculiar ferment, which possesses properties analogous to those found, by M. Cagniard Latour, to exist in yeast.

This ferment is composed, as shewn by microscopic examination, of globules varying in diameter from the $\frac{1}{400}$ to the $\frac{1}{150}$ of a millimètre. They are insoluble in alkalies, acids, and æther. Some of them completely resemble the globules of the blood.

M. Biot has recently made an application of his researches upon the deviation of the rays of polarized light, which bears upon the subject in question. Grape sugar in solution, possesses the property of deviating the ray of polarized light to the right, and it has been shewn by M. Biot, that diabetic urine does the same; this, however, is not surprising, since diabetic sugar is identical with grape sugar.

Spermatic Fluid.—The intermixture of the spermatic fluid with the urine, which may occur under certain circumstances, gives to the latter the following characters:

1. A semi-transparent mucus-like cloud is observed, which usually falls, after a certain time, to the bottom of the vessel.

2. The urine contains a very small quantity of albumen, as demonstrated by the application of heat.

3. The microscope reveals the presence of spermatozoa. They live for a very short time in the urine, but may always be recognized in the deposits.

If the urine at the same time contain pus, the purulent deposit formed at the bottom of the vessel carries along with it the spermatozoa, which may exist for a short time in the midst of the deposit.

Bile.—In certain cases of hepatic disease, the urine presents an appearance indicative of the presence of bile; but it has not as yet been ascertained whether the bile itself passes into the urine, or merely its colouring principle.

The recognition of bilious urine is based upon the following tests:

1. Its appearance as regards colour;
2. The immersion of linen, which assumes a yellow tint;
3. The action of nitric acid, which produces at first a green colour, eventually passing into a brownish red.

Occasionally the epithelial scales found in bilious urine present a yellow colour.

Urinary deposits, and more especially those composed of uric acid, seldom carry down with them the colouring matter of the bile. This may, however, occasionally happen, and they then assume a yellowish green colour.

Medicinal agents and poisons occasionally found in the Urine.—It would appear to be a law of life, that all parts of the organism have a constant tendency to maintain their original identity of composition. Whenever, therefore, a foreign substance has been introduced by absorption into the economy, whether through the medium of the cutaneous surface or of the digestive organs, this substance, if not adapted to the nutrition of the individual, in other words, if not assimilable, must be eliminated after a certain length of time. Such is the case with the majority of medicines, whether poisonous or not; and of which, after a variable period of time subsequent to their administration, not a trace can be detected in the economy. Some medicinal agents are not, however, completely eliminated, being destined to repair some loss, as in the case of iron when given to chlorotic patients.

Every medicine or poison, therefore, introduced into the economy, is either partially or completely eliminated in a given space of time. This process takes place through the medium: 1. Of the cutaneous surface; 2. Of the respiratory organs; 3. Of the digestive organs; and 4. Of the urine.

It is of the latter alone that we shall here speak.

Of the various poisons or remedies which may be introduced into the system, a certain number cannot be detected in the urine; others are only found there after having undergone some change; while some may, by a chemical process, be recognized in their primitive condition.

We must here remark, however, that the value of experiments made relative to the subject in question, is not the same in all cases; certain substances, found by one experimenter, having escaped the observation of others. This is doubtless owing to the very small amount of these substances passing into the urine, and to the various conditions which this fluid may present at the moment of elimination.

Of the substances which have not hitherto been detected in the urine, we may mention the following:

1. The mineral acids, sulphuric, nitric, and hydrochloric;
2. Alcohol;
3. Lead;
4. Bismuth;
5. Camphor;
6. Musk;
7. Alkanet.

These substances have been more especially sought for in the urine.

A certain number of foreign matters pass into the urine after having undergone some special alteration.

The acetates, citrates, and tartrates of potash and soda, enter the urine, according to Wœhler, as subcarbonates of these bases.

Oxalic acid and the oxalates are found in the urine as crystals of oxalate of lime.

The following substances have been found in the urine:

1. *Iodine.*—Its presence in the urine has long been noticed. We ourselves have made some experiments upon the renal secretion of scrofulous children who were taking iodide of potassium.

To detect this substance, the urine must be treated with sulphuric acid and chlorate of potash. From the mutual reaction of these two substances results the disengagement of chlorine, which takes the place of the iodine in the iodide. The iodine, thus set free, may readily be detected by adding a solution of starch, when the characteristic blue iodide of starch is formed.

Having examined the urine of many persons while taking the iodide of potassium, we have arrived at the following conclusions:

1. The iodide of potassium invariably enters the urine, and its presence there may be easily demonstrated.

2. When continued for a length of time, and more especially when saturation of the system, as it were, begins to take place, a very large quantity of iodine escapes from the system along with the urine.

3. The amount of iodine, so escaping, varies considerably; if the urine be examined every time it is passed, for several days in succession, some specimens will be found to contain much and others but little. No fixed law, of which we are cognizant, appears to regulate these variations.

4. The administration of aqueous, alcoholic, or ætherial solutions of iodine, produces identical results.

In spite of all that has been said, the preparations of iodine may be classed among those remedies which have the least tendency to be assimilated and retained by the economy. They appear to escape on every side; and so true is this, that if iodine be taken, its taste will reappear in the mouth after two or three hours' interval; it irritates the throat, and produces a sensation of dryness and acridity. This is owing to an elimination of the iodine by the parts affording the sensations in question. We have ourselves frequently repeated these experiments, and always with the same results.

2. *Mercury.*—According to M. Canter, mercury may be detected in the urine.

3. *Arsenic and Antimony.*—Foderé had already announced the passage of the former metal into the urine. But the most remarkable and convincing experiments in this respect, were those made by M. Orfila. The following is a resumé of his researches:

Whenever arsenic or antimony, in any form (whether as arsenious acid or tartar emetic), are introduced into the system, either through the medium of the digestive organs or of the cutaneous surfaces, they act as foreign matters, which require to be eliminated, provided death do not take place before this process commences.

This elimination usually occurs through the medium of the kidney, and is consequently more prompt and easy in proportion to the amount of urine passed by the individual. M. Orfila found, that animals which he had poisoned, sank rapidly when there was no secretion from the kidneys; whilst those which passed water freely and abundantly, recovered.

These are facts of great importance, on account of the therapeutic indications which they afford, especially with regard to the administration of diuretics. By encouraging the action of the kidneys, we thus favour the elimination of the poison.

Arsenic and antimony are found in the urine, very shortly after being taken into the system.

Various means may be employed for the detection of these substances; we extract the following details from the lectures given upon this subject by M. Orfila. The apparatus employed was that of Marsh, of which we need not here speak, nor of the differential characteristics of antimonial and arsenical stains.

1. Arsenic may be detected by taking the suspected urine, mixing it with a certain quantity of olive oil (an ounce, for example), and placing the mixture in Marsh's apparatus, when arsenical spots will soon appear; the same may be said of antimony.

It is better, however, to adopt one or other of the following processes:

2. The urine is first to be evaporated to dryness, then carbonized and exposed to the action of boiling hydrochloric acid, diluted with one quarter of its weight of water. The solution is now to be introduced into Marsh's apparatus, previously tested, and the characteristic spots of metallic arsenic or antimony are to be carefully sought for.

3. The urine is evaporated to dryness in a porcelain capsule, after being mixed with a small proportion of alcoholic solution

of potash. The dry product is now heated over a slow fire, and constantly shaken, until it acquires the colour of roasted coffee. It is then treated, for about a quarter of an hour, with pure boiling hydrochloric acid, diluted with one third its weight of water.

The filtered liquid is now introduced into Marsh's apparatus, previously tested, and metallic stains of arsenic or antimony are then to be sought for.

The same phenomena occur in man as in animals. Thus, M. Orfila discovered arsenic in the urine of a woman suffering from a skin disease, for which she had, for two months and a half, taken daily very small doses of Fowler's solution; he likewise detected antimony in the urine of several females who had been treated with tartar emetic, according to the method of Rasori:

The following substances have likewise been detected in the urine:

4. Chlorine, according to M. Chevalier;
5. Silica;
6. Succinic acid;
7. Hydro-sulphuric acid, according to Wœhler;
8. Sub-carbonate of soda;
9. Chlorate of potash;
10. Yellow ferrocyanide of potassium.

We have ourselves made some experiments relative to this latter substance, but were unable to detect its presence in the urine. It is true that the persons to whom it was administered, and in whose urine it was sought for, never took more than twenty-seven grains per diem.

11. Chloride of barium;
12. Nitrate of potash;
13. Sulphate of quinine (Quevenne);
14. Indigo. An epileptic patient, treated with indigo, and who took nearly one drachm daily, invariably passed blueish green urine.
15. Iron. Our experiments with respect to this metal are numerous and convincing; they were made upon eight chlorotic

females, in the wards of M. Guéneau de Mussy; the treatment to which they were submitted, consisted (in seven cases) in the administration of ferruginous bread, containing either the carbonate or lactate of iron; and, in one case, of pills of subcarbonate of iron.

The urine was examined daily, and the following conclusions drawn:

If a portion of the iron passes off by stool, as is indicated by the colour of the evacuation, a large amount likewise passes off by the urine.

It may be found in urine passed during every period of the twenty-four hours.

The quantity found in the urine varies much, although the amount of iron daily administered may be the same.

The two following processes may be employed for the detection of iron in the urine; of these, one is far more delicate and accurate than the other:

1. The urine is treated as though the object were the extraction and analysis of the inorganic salts; the iron is contained in the saline mass, which on this account sometimes assumes a blueish tint. This mass is first dissolved in water acidulated with hydrochloric acid, and then treated with ferrocyanide of potassium, which detects the smallest quantity of iron.

2. The following process is very simple, and may be employed at the bedside of the patient. A given quantity of urine is boiled with nitric acid, and ferrocyanide of potassium added. The nitric acid is employed for the purpose of still further oxidizing the salts of iron.

If there be but a small quantity of iron in the urine, the fluid merely assumes a greenish colour, due to the combination of Prussian blue with the colouring matter of the urine.

Should the urine contain a large proportion of iron, we notice, in addition to the green colour, flakes of Prussian blue.

The following process may likewise be mentioned, although its employment is too tedious to admit of practical application:

The specimen of urine supposed to contain iron, is allowed to decompose spontaneously; the decomposition of the urea gives rise, as we have shewn, to certain organic products. These products, spontaneously developed, enter into combination with the iron existing in the urine, and Prussian blue is thus deposited.

SECT. VIII.—Of the Physical Properties of the Urine.

Under this title may be comprehended:

1. Quantity;
2. Specific gravity;
3. Colour;
4. Consistence;
5. Transparence;
6. Odour.

1. OF THE QUANTITY OF THE URINE.

The sum total of the urine passed by an individual in the space of twenty-four hours is made up of two distinct elements: 1. The water; and 2. The aggregate of solid matters held in solution. To this subject we have already alluded, and shall therefore treat here, merely of the actual quantity of the urine.

As the result of a large number of experiments, M. Becquerel has been enabled to state the mean amount of urine to be as follows:

Males	1267.3
Females	1371.7
Mean of both	1319.5

These numbers are liable to variation: and therefore the above authority places the physiological limits at from 900 to 1500 grammes of urine in the twenty-four hours,* the water alone being subject to variation, but the solid matters remaining unaltered.

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* From twenty-eight to forty-six ounces.

In disease, the amount of urine often does not exceed the limits of health. This usually happens in cases where the disease is slight, and the principal functions but little deranged.

It occasionally happens, that in persons presenting marked febrile symptoms and functional derangement, the quantity of urine does not diminish. This is particularly the case where a large amount of liquid has been taken by the patient.

Increased flow of Urine.—Of this the causes are as follows:

1. The introduction into the economy of an unusual amount of water;
2. Polydipsia;
3. Diabetes;
4. Polyuria;
5. The hysteric paroxysm.

In this last case the increased flow is accidental, and merely momentary.

When the products of the urinary secretion are increased by the addition of an unusual amount of water, not only does the water alone pass off by the kidneys, but it invariably carries along with it a much larger amount of solid matters than usual.

M. Becquerel, having experimented upon a man who passed in twenty-four hours about thirty-two ounces of urine, containing somewhat more than an ounce of solid matters, found that under the influence of an unusual amount of water introduced into the system during the same space of time, a considerable increase of these solid matters took place in the urine. Thus, he found eighty-four ounces and a-half of water, and nearly one and a-half ounces of solid matters.

Diminished flow of Urine.—The causes giving rise to this occurrence are more frequent than those, under the influence of which the flow of urine is increased. They are as follows:

1. Fever, from whatever cause it may have arisen;
2. Functional derangements of moderate severity;
3. Profuse evacuations (diarrhœa, sweats, etc.);
4. The latter stages of heart disease;

5. Diseases of the liver.

In these cases it is the water which undergoes the greatest diminution in point of quantity; the aggregate of solid matters held in solution by it, likewise decreases, but in considerably less proportion; they are thus concentrated in the urine, which becomes darker, more loaded, of higher specific gravity, and contains a proportionately larger amount of solid matters.

2. OF THE SPECIFIC GRAVITY OF THE URINE.

The specific gravity of the urine is liable to great variations, and some have gone so far as to assert, that all investigations respecting it were absolutely useless (Darcet). This proposition, however, is much too sweeping, and can only have arisen from the urine having been considered abstractedly, and without reference to the actual amount secreted in twenty-four hours. Indeed, all experiments relative to the specific gravity of the urine, are only of value when placed in juxtaposition with the total amount of fluid secreted in that time. Under other circumstances, the specific gravity can but serve to shew the relationship existing between the solid matters and the amount of urine actually under examination. To ascertain the specific gravity of the urine various means may be employed. Of these, the specific gravity bottle is certainly the most accurate; in this, distilled water and urine are successively weighed at the same temperature; the results being referred to the numerical standard of 1000. This process is but rarely adopted, being tedious and delicate. Recourse is more frequently had to Baume's aerometer, especially constructed for liquids of greater density than water. To use the instrument in question, nothing more is necessary than to plunge it into the urine, and to notice the degree to which the instrument sinks.

We shall now proceed to consider the variations to which the specific gravity of the urine is liable.

1. *Ordinary Specific Gravity.*—The ordinary specific gravity of the urine may be represented by a mean of 1017.010, or by figures varying from 1016 to 1018.

Three cases may here present themselves :—*a*. The amount of urine secreted in twenty-four hours does not exceed the limits of health, viz., forty ounces—this being about the average ; *b*. It is increased in quantity, the specific gravity, however, remaining unchanged, and a larger amount of solid matters therefore being held in solution ; *c*. The quantity of urine is diminished, the specific gravity still remaining as before. This indicates a proportional decrease on the part, not only of the water, but of the matters held in solution.

2. *Increase of the Specific Gravity.*—This indicates that the natural proportion of solid matters to the water, no longer exists ; the former are increased in quantity, the latter diminished.

Three cases also may here present themselves.—*a*. Diminished amount of urine, with increased specific gravity. This is of most frequent occurrence in fevers and in severe functional derangements, etc. Its significance varies with the amount of urine secreted. It usually, however, indicates a diminished proportion of water, with a comparatively less decrease of the soluble matters of the urine.—*b*. The quantity of urine remains within the limits of health, while its specific gravity is increased. This indicates a greater or less increase of the soluble matters.—*c*. There may be a simultaneous increase both in the quantity of urine and in its specific gravity. This indicates a very considerable augmentation of the matters held in solution (diabetes, polyuria).

3. *Decrease of the Specific Gravity.*—This indicates an inverse change in the ratio existing between the water and the soluble matters, to that mentioned in the preceding paragraph. Three cases may here likewise present themselves : 1. A natural amount of urine ; this shows a decrease in the soluble matters ; 2. Diminished amount of urine, with low specific gravity ; this indicates, still more, a decrease of the solid matters ; 3. Increased amount of urine, with decrease of its specific gravity. In this case, all depends on the degree of increase, inasmuch as the increase of the water and the decrease of the

specific gravity, may so neutralize each other as to represent the density of healthy urine.

3. OF THE COLOUR OF THE URINE.

The colour of the urine is one of those physical properties to which all Hippocratic physicians have paid very considerable attention. It has likewise been carefully noticed by subsequent authorities. In the works of Prosper Alpinus, Actuarius, etc., there are a variety of curious documents respecting it.

Normal Colour of the Urine.—This is due, as we have already stated, to the presence of a specific colouring matter. We require to distinguish three shades of colour, as peculiar to urine, these are:

A greenish tint, as seen in pale clear urine;
A yellowish tint, in healthy urine;
A reddish tint, in high-coloured urine.

Almost all the variations of colour attributed to healthy or morbid urine, may be referred to these three fundamental shades.

High-Coloured Urine.—It may be of a deep yellow, of a saffron yellow, reddish yellow, and sometimes even of a blood red hue, without, however, containing blood. The darkest tints usually correspond with a marked decrease in the amount of urine secreted in twenty-four hours, and with an increased proportion of uric acid and soluble organic matters. These two phenomena occur simultaneously; and we conclude by induction, that both the uric acid and the organic matters are more abundant, in proportion as the urine is high coloured.

The black urine of the ancients appears to be nothing more than urine containing a large amount of colouring matter, blood or bile.

Pale urine has generally a light yellow or greenish tint. A pale colour of the urine coincides, for the most part, with an increased proportion of water and a decrease of the soluble matters. Urine of this kind is generally of low specific gravity.

Alkaline urine is almost always pale, and it would appear that alkalinity of the urine possesses the property of destroying the colouring matter.

Urine Coloured by Foreign Matters.—One or other of the following substances may impart an unusual colour to the urine:

1. *Blood.*—That this is the occasional cause of discoloration of the urine, may be abundantly proved by inspection, by the application of heat and nitric acid, and by microscopic examination.

2. *Bile.*—Its presence in the urine may be demonstrated by immersing a piece of linen in the suspected fluid, or by the addition of a few drops of nitric acid, which will produce a greenish tint if bile be present.

3. *Pus.*—This gives to the urine a pale yellow or dirty white colour; at the same time a deposit is formed at the bottom of the vessel.

4. OF THE CONSISTENCE OF THE URINE.

It may be either thick or thin; the latter containing but little, if any, mucus.

The former comprises the following varieties. 1. Urine loaded with mucus. 2. Urine containing pus. 3. Alkaline urine, especially that which contains mucus, for in such cases a species of ammoniacal soap is formed. 4. Urine containing blood. 5. Strongly acid urine, of a dark colour, and loaded with organic matters. Such urine almost invariably produces, owing to its irritant qualities, an increased secretion of mucus from the bladder.

5. OF THE TRANSPARENCY OF THE URINE.

A variety of substances may produce turbidity of the urine. We must consider separately, that which may be engendered, first, in acid, and secondly, in alkaline urine.

Acid Urine.—Acid urine may be perfectly transparent, whatever be the amount of soluble matters held in solution.

Its transparency may be diminished: 1. By mucus. 2. By pus. 3. By blood; in some cases this latter appears in the form of a clot; at others, it is diffused throughout the liquid, giving it a turbid appearance. 4. By organic detritus, formed of decomposed blood. 5. By the ordinary deposits of acid urine, viz., uric acid and acid urates: in such cases, these deposits are formed, at one time in the bladder, at another, while the urine is cooling, after emission. 6. By fatty matters.

Alkaline Urine.—Alkaline urine may be rendered turbid by the presence of mucus, pus, blood, spermatic fluid, and organic detritus; the difference between acid and alkaline urine, on the score of transparency, lies in the nature of the saline deposits, these are composed of the following substances: ammoniaco-magnesian phosphates, phosphate of lime, carbonates of lime, and magnesia. There is usually much mucus present in such cases.

6. OF THE ODOUR OF THE URINE.

The odour of the urine varies considerably; being most marked, however, in those cases where the fluid is much loaded and of high specific gravity. Pus and the leucorrhœal discharge of females impart an odour to the urine. In parturient women, the lochia communicate a peculiarly disagreeable odour to this fluid.

When urine becomes alkaline, it has an ammoniacal odour.

SECT. IX.—General Summary of the Physiological and Pathological Changes to which the Urine is liable.

In this article we shall endeavour to offer a *resumé* of all that we have hitherto stated respecting the urine. Having considered the subject analytically, we shall now do so synthetically.

The urine of a man of sound constitution, who is in good health, eats moderately, drinks merely to satisfy his thirst, and takes a proper amount of exercise, is a yellowish liquid, having occasionally a greenish or saffron tint, and of which from twenty-eight to forty-seven ounces are passed in the twenty-four hours.

Its specific gravity depends on the amount of water it contains. On this account it varies from 1014 to 1024.

It is acid. The proportion of water varies from twenty-eight to forty-seven ounces. It is under the influence of the amount of water introduced into the system, being increased by a copious imbibition of fluid. It diminishes, on the contrary, under the following circumstances: 1. A stimulant and highly nitrogenized diet; 2. Excess of any kind, except of liquids, of which the primary effect is an increase, and the consecutive result, a decrease of the water; 3. Undue muscular exertion; 4. An elevated temperature and copious perspiration; 5. A fit of anger; this is comparatively rare.

The aggregate of chemical constituents held in solution increases, whenever an unusual quantity of water is introduced into the system; it decreases under the influence of a restricted regimen.

On this point, M. Chossat has arrived at some curious results, which may be summed up thus:

1. It may be stated as a rule, that the urine is more copious and of lower specific gravity, in proportion as the conditions in which the individual is placed, are favourable to the introduction of water into the system.

2. If we leave out of the question, the variable amount of water contained in the urine passed by an individual in a given time, and consider merely the quantity of solid matters, we shall find that this quantity increases, decreases, or remains stationary with articles of diet of a similar nature, and varies with those of a different nature, but of which the proportions are still the same.

3. The quantity and quality of aliment taken, being the same in a given space of time, and, as a consequence, the sum total of the solid matters of the urine being the same during a similar period; the actual secretion of these solid matters, in relation to the period at which it takes place, undergoes

marked variations, dependent upon the time which may have elapsed since the taking of food, and upon the periods of fatigue and repose.

The following experiments of M. Lecanu have especial reference to the chief chemical constituents of the urine.

1. The amount of urine passed by different individuals varies, whether we experiment upon persons placed under totally different circumstances, or upon those whose circumstances are identical. This amount varies from fourteen to seventy ounces. The mean, as ascertained in a large number of cases, may be stated at from thirty-nine to forty ounces.

2. The quantity of urine voided on each occasion during the twenty-four hours, by the same individual, is liable to variation. It frequently happens, however, that the entire amount passed by this same individual during several consecutive periods of twenty-four hours duration, remains almost stationary during similar periods; or when the circumstances, under the influence of which the variations previously noticed took place, are reproduced with tolerable uniformity.

3. Nothing can be concluded with certainty respecting the amount of urine, from an examination of its colour, and *vice versa*.

4. The specific gravity of the urine is higher in adult males than in females, in children, or in the aged.

5. The specific gravity of the urine of a given individual generally remains the same; to this, however, there are certain exceptions.

6. M. Lecanu asserts, that the innate vigour shown to exist in man, by a large proportion of the essentially stimulant principle of the blood (the globules), is equally demonstrated by the abundance of that which is the characteristic principle of the urine (the urea), and possibly, likewise, by a large proportion of the essentially characteristic constituents of every secretion.

7. The secretion of urea does not appear to be favoured by the passage of a large amount of water through the urinary apparatus. This we ourselves have proved.

8. The more dense specimens of urine usually contain the

largest amount of urea; this is not, however, always the case, inasmuch as the proportion of urea may be modified by the presence of salts.

9. M. Lecanu conceives that the uric acid is less susceptible of variation than the urea, and that it is likewise less under the influence of age and sex.

10. The quantity of fixed matters undecomposed by heat, varies in different individuals, and even in the same person at different times. It is generally greater in the adult than in old men, women, and children; as is also the case with the urea.

We shall terminate this summary of the admirable researches of M. Lecanu, by quoting the five concluding propositions of his memoir.

1. An equal amount of urea is secreted during equal periods of time, by the same individual.

2. The same proposition holds good with respect to the uric acid.

3. The urea and uric acid are secreted in variable quantities, during similar periods of time, by different individuals.

4. The proportion of urea secreted by different individuals during equal periods of time, depends on the age and sex of such individuals: it is greater in men at the prime of life than in females at a similar period: in children and in the aged the proportion is likewise less.

5. The aggregate of the fixed matters of the urine, undecomposed by heat, such as the sulphates, phosphates, and chlorides, is secreted in variable proportions, without reference to the age or sex of different individuals; and in no less variable proportion in the same individual during equal periods of time.

We conceive that the propositions here quoted from the admirable memoir of M. Lecanu, deserve to be admitted as facts.

There are certain physiological conditions by which the urine may be somewhat similarly modified. This modification consists in a decrease of the water, a concentration of the urine, and an increase of the uric acid. The urine is, consequently, of higher specific gravity and darker in colour. In such cases the excess of uric acid is not unfrequently deposited spontaneously, forming sediments of various colours.

Under the influence of certain causes hereafter to be enumerated, it may be stated, that the urine decreases and becomes concentrated merely by a diminution of its watery portion, while the proportion of uric acid increases. These physiological conditions are as follows :

1. *Diet.*—Thus, too stimulating or nutritious food, whether taken constantly or only occasionally : in the former case the modification of the urine is permanent, in the second it is accidental.

2. *Stimulant drinks,* such as *wine, coffee, tea, liqueurs.* These produce, as we have already stated, a two-fold result ; the first being an increased secretion of water by the kidneys, and the second, the peculiar modification of which we are now treating.

3. *Great Muscular Exertion.*—This may readily be explained by the increased consumption of carbon, the corresponding increase of animal heat, and the consequently augmented residuum of nitrogenized matters requiring to be eliminated by the kidneys.

4. *Increased Action of the Skin.*

5. *Violent Moral Emotions of all Kinds.*—Here, again, the results may be two-fold : the first being the excretion of a large quantity of *clear, limpid urine;* the second, of concentrated urine, rich in solid matters.

6. *Prolonged Sleep, together with a habit of Rarely Micturating.*—This may be explained by the re-absorption of a portion of the water.

SECT. X.—Of the Pathological Changes of the Urine.

Almost all writers on general pathology, whether ancient or modern, have devoted long articles to the study of the urine. We would here refer the reader to the historic portion of M. Becquerel's work, entitied, *De la Séméiotique des urines.*

Morbid urine may be classed under four heads, each of which again presents certain distinct varieties.

First Class.—Febrile urine.
Second Class.—Anæmic urine.
Third Class.—Alkaline urine.
Fourth Class.—Urine differing but little from that of health.

FIRST CLASS.—FEBRILE URINE.

It is thus designated, inasmuch as fever is usually the morbid condition in which it appears. This, however, is not invariably the case.

It presents three varieties.

1. Febrile urine, properly so called.
2. Febrile urine, accompanied by some cause of debility.
3. Febrile urine, in which the proportion of water has not undergone a marked decrease.

FIRST VARIETY.—*Febrile Urine, properly so called.*—This variety of urine presents the following modifications: Marked decrease in the proportion of water; less proportional diminution of the aggregate of chemical constituents held in solution, and hence, concentration of the urine; decrease of the urea; increase of the uric acid (its proportion may be doubled); decrease of the organic salts, while the organic matters, strictly so called, may either remain unchanged, or undergo at one time a slight augmentation, at another a trifling diminution. We here subjoin the mean of eleven analyses taken from the work previously quoted.

Amount of urine passed in twenty-four hours	660.364
Water	685.050
Amount of matters held in solution	24.686
Specific gravity	1021.840
Urea	8.996
Uric acid	0.999
Inorganic salts	4.849
Organic salts	9.842

Fever, however caused, may produce these modifications of the urine; and they are always proportionate to the intensity and duration of the disease.

Some authors have imagined, that these modifications of the urine were only produced at the close of fevers and feverish attacks in general, and that at this time only, did the uric acid become increased in quantity, and form a deposit; in other words, they conceived such urine to be critical.

We have shown, however, in another work, that this is not the case, inasmuch as these deposits may appear at any period of the fever, and are therefore by no means to be regarded as critical. We shall not here discuss the point, contenting ourselves simply with stating, that those copious brick-dust deposits, of which authors have so frequently spoken as occurring at the close of an ague fit, do not differ, as regards composition, from those which appear in the urine during continued fevers. In these, indeed, they are simply the result of the intensity of the fever, without reference to its nature.

We may here ask, whence the cause of this characteristic modification of the urine as indicated by the following phenomena:—1. Diminished proportion of water; 2. Proportionally less diminution of the sum total of solid matters; 3. Increase of the uric acid?

Of these three modifications, the second is especially due to the influence of low diet. As for the others, may they not depend upon an increase of the natural heat of the body? Might we not, moreover, suggest an increased action of the skin, as occurring under the influence of a higher temperature of the system at large, and thus carrying off the water which should be eliminated by the kidneys? Might we not again ask, whether they ought not to be attributed to increased activity of the renal circulation, and to a species of renal hyperæmia, produced under the influence of fever? To such questions we are unable to give a decisive answer; we merely know the facts, without being able to offer any satisfactory explanation thereof.

The febrile condition is not the sole cause capable of giving rise to this first variety of so-called febrile urine; the following may likewise be mentioned:

a. Functional derangement of one or more organs, with or without change of structure.

b. A general hypersthenic condition of the system.

c. Acute and chronic phlegmasiæ.

d. Diseases of the liver, heart, and lungs, when far advanced.

e. Hæmorrhages, but only while they last.

f. Organic degeneration of various organs, capable either of producing a febrile condition, or functional derangements.

g. The action of purgatives.

The energy of these causes is in proportion to their own intensity.

SECOND VARIETY.—*Febrile urine accompanied by some debilitating cause.*—By this we understand febrile urine secreted under circumstances analogous to those just mentioned, with this addition, that the individual presents some cause of debility or exhaustion, producing certain special modifications of the urine, which are as follows:

Diminished proportion of water, as in the former variety.

Great decrease of the soluble matters.

Low specific gravity.

Two causes operate in this instance: 1. Restricted regimen; 2. The nature of the disease, together with the measures taken for its removal.

In this general decrease of the solid matters of the urine, we find a smaller proportion of urea, a normal or increased proportion of uric acid, concentrated, moreover, in a smaller quantity of water than usual; and a decrease of the inorganic salts and organic matters.

The following table shews the composition of such urine:

Urine secreted in twenty-four hours	608.916
Specific gravity	1014.700
Water	643.147
Soluble matters	15.769
Urea	4.456
Uric acid	0.497
Inorganic salts	4.392
Organic matters	6.424

This variety of urine is secreted under circumstances similar to those which give rise to febrile urine in general; and to which may be added, the exhaustion and debility engendered by the duration and severity of the disease; the adynamic character of the affection itself; and the debility produced by natural or artificial loss of blood, repeated purgation, etc.

THIRD VARIETY.—*Febrile urine, in which the proportion of water is not diminished.*—This comprehends those specimens of febrile urine, which might be ranked under the first and second variety, *quoad* the amount of soluble matters secreted in the twenty-four hours; were it not that the amount of water by which these matters are held in solution, varies.

The following are the chief characteristics of this variety of febrile urine.

a. The water undergoes but a trifling change; it may either be slightly increased or decreased.

b. The aggregate of soluble solid matters undergoes a diminution, about equal to that which occurs in the first and second variety of febrile urine.

c. The proportion of urea is diminished.

d. That of the uric acid remains either unchanged, or is slightly increased.

e. The inorganic salts and organic matters are diminished in quantity.

The only real difference, therefore, consists in the proportions of water and uric acid remaining unchanged.

The following table shews the mean composition of this variety of febrile urine:

Amount of urine passed in twenty-four hours	1301.500
Specific gravity	1010.500
Water	1279.069
Soluble matters	22.431
Uric acid	0.378
Inorganic salts	3.320
Organic matters	9.834

The absence of change on the part of the water is not well accounted for. Sometimes it may be explained by the large amount of fluid imbibed; but this alone is not a sufficient solution of the problem, for we frequently meet with fever patients, whose urine presents all the characteristics of the true febrile variety, although they drink as much as three or four pints of fluid per diem.

SECOND CLASS.—ANÆMIC URINE.

The term *anæmic* does not necessarily imply that this variety of urine is only met with in chlorosis and anæmia. It is so designated, merely from being especially characteristic of these two morbid conditions.

We admit two varieties of this urine:

1. Anæmic urine, properly so called.
2. Concentrated anæmic urine; in which there is a marked decrease of the water and a proportionately less decrease of the soluble matters.

FIRST VARIETY.—*Anæmic urine properly so called*—The following are its chief characteristics. 1. The proportion of water either remains unchanged, or undergoes a slight diminution. 2. The quantity of matters held in solution is much diminished. We here include the urea, uric acid, inorganic salts, and organic matters.

The following table shews the mean composition of such urine.

Amount secreted in twenty-four hours	1122.910
Specific gravity	1010.380
Water	1102.874
Soluble matters	19.036
Urea	7.211
Uric acid	0.281
Inorganic salts	4.648
Organic matters	6.896

The causes which give rise to this variety of urine are anæmia, however produced, and chlorosis.

Of the different forms of symptomatic anæmia, and they all may act in this direction, we must especially notice that which marks the convalescence from acute and chronic diseases.

Repeated loss of blood, whether natural or artificial, may give rise to this variety of urine; but as a secondary consequence only, and provided there be no febrile symptoms.

In the chronic form of Bright's disease, the urine is anæmic, independently of the albumen which it contains.

It may be asked, are we to seek for the cause of anæmic urine in the impoverishment of the blood, in the languid condition of all the organic functions, or in both of these conditions? Probably so, but we cannot undertake to prove it.

From anæmic urine, properly so called, we require to distinguish that to which the term pseudo-anæmic might with more propriety be applied, and which results from the introduction of a large amount of water into the system.

SECOND VARIETY.—*Concentrated anæmic urine, in which there is a marked decrease of the water and a proportionately less decrease of the soluble matters.*—The following are the chief characteristics of this variety of anæmic urine.

a. Marked decrease in the proportion of water.

b. Diminished amount of soluble matters; the decrease, however, being less than in the first variety.

c. Decrease of the urea, uric acid, and inorganic salts.

d. The organic matters but little affected.

The following are the mean results afforded by several analyses.

Amount of urine passed in twenty-four hours .	907.370
Specific gravity	1017.640
Water	882.072
Soluble matters	25.298
Urea	6.245
Uric acid	0.342
Inorganic salts	7.900
Organic matters	10.811

Urine of this description occurs in slight cases of anæmia and chlorosis.

It is likewise seen in cases where, in an anæmic individual, there are either developed febrile symptoms, or tolerably well-marked functional derangement; although in such cases it may happen that the urine presents the characteristics of the second and third variety of the so-called febrile urine.

In some cases, we are unable to account satisfactorily for this species of urine.

THIRD CLASS.—ALKALINE URINE.

This is always the result, as we have already stated, of the decomposition of the urea, occurring either when the urine is first secreted, or while in the bladder; usually the latter.

The following causes may give rise to this decomposition:

1. Certain diseases of the kidneys; acute and chronic nephritis;
2. Certain cases of Bright's disease;
3. Stagnation of urine in the bladder;
4. Diseases of the bladder, accompanied by purulent secretion;
5. Certain diseases of the brain and spinal?

FOURTH CLASS.—URINE DIFFERING BUT LITTLE FROM THAT OF HEALTH.

This frequently occurs in apyrexial diseases, and in nervous affections, etc. We need but state the fact.

Sect. XI.—Of the Modifications of the Urine in Particular Diseases.

These may almost be foreseen: in fact, it is sufficient to apply the principles already enunciated, to be enabled to state beforehand, the composition and properties of the urine in disease.

We shall endeavour to treat the subject as rapidly, but as succinctly as possible.

FIRST GROUP.—THE PYREXIÆ.

Under this head we shall consider the urine in typhoid fever, measles, scarlet fever, small pox, and intermittent fever.

A. TYPHOID FEVER.

The researches contained in our former work, *De la Séméiotique des urines*, are those upon which we shall chiefly rely.

In typhoid fever, as long as the febrile condition is well marked and the adynamic period but slightly so, the urine presents the true febrile character: it is scanty, high-coloured, loaded with uric acid, of high specific gravity; it sometimes contains a small quantity of blood or albumen, and occasionally a very large amount of mucus; it has, moreover, a great tendency to decomposition on leaving the bladder.

When the adynamic stage has fairly set in, one of two things may happen:

1. If the febrile symptoms are very severe, the urine generally presents the characteristics of the second variety of febrile urine.

2. If, on the contrary, they are of but moderate severity, the urine presents the anæmic character: it becomes pale, of low specific gravity, and contains but little deposit.

To either of the above cases, exceptions may occur.

There is another circumstance to be noticed respecting the urine in typhoid fever, viz., its stagnation in the bladder. In such a case, it contains a large amount of mucus, becomes alkaline, and, should it continue to remain in the bladder, inflammation of that organ may be produced, imparting to the urine the usual appearances noticed in ordinary cystitis.

Certain questions of importance here suggest themselves: 1. Do the deposits of uric acid appear at stated periods of the fever? 2. Does their presence indicate a favourable termination of the disease? 3. Are they to be regarded as critical? These questions we are enabled to answer in the negative.

The uric acid, of which the proportion is always greater than natural, sometimes remains in solution, at others, it is spontaneously deposited; occasionally requiring, however, the addition of one or two drops of nitric acid. These different indications of an increased amount of uric acid, may occur separately, alternating sometimes the one with the other.

Hence, sedimentary urine is of no more importance than scanty, dense, high-coloured urine; but as the excess is indicated in the former by a new physical peculiarity, we may dispense with that analysis which the latter requires.

We may again briefly recapitulate the changes which occur in the different constituents of the urine:

a. A considerable diminution of the water;

b. A proportionately less decrease of the soluble matters;

c. A decrease of the urea;

d. An increase of the uric acid;

e. A decrease of the salts, equivalent to that of the urea;

f. The organic matters either remain unchanged, or are slightly increased.

The quantity of mucus is sometimes increased, more especially when there is retention of urine. This increase is more frequent in females than in males, but it is the result of leucorrhœa, and not of the typhoid fever.

Blood is rarely met with in the urine of typhoid fever. In our own experience, as recorded in the work previously quoted, it occurred twice in thirty-eight cases, and then only for a short time.

Whenever the urine of persons suffering from typhoid fever contains pus or blood, it is found likewise to contain albumen; but it may occasionally be detected in the urine, irrespective of the presence of either. Thus, of the thirty-eight cases mentioned above, eight afforded indications of albuminous urine, the quantity of albumen, however, being very small, and its appearance transitory. The general characters of the urine, moreover, did not seem to be much affected by its presence, as in the case of Bright's disease. We may here notice a not unimportant fact, viz., that in two of the severest cases of fever, the urine contained albumen during the last week of the disease.

During convalescence, the chemical constitution of the urine depends upon the general condition of the patient. In severe cases, it is anæmic; in moderate cases, it is sometimes normal, and at others anæmic; in mild cases it is perfectly natural.

B. RUBEOLA.

The composition of the urine in measles, is due to a variety of circumstances requiring special notice. It should be studied:

1. During the premonitory fever;
2. During the eruption;
3. During the stage of desquamation and convalescence.

During the feverish stage which precedes the appearance of the eruption, it presents all the characteristics of febrile urine; and on very rare occasions, a trace of albumen may be detected; this, however, is quite an exceptional occurrence.

During the eruptive stage, the urine continues to present the same appearances, provided the feverish symptoms do not abate. Should they do so, however, the urine, in spite of their cessation, may either retain its febrile characteristics, or rapidly regain its normal condition.

During desquamation and convalescence, the urine undergoes changes identical with those which occur during convalescence from acute diseases in general.

When measles are complicated with one or other of the phlegmasiæ, and that the fever persists after the disappearance of the eruption, the febrile character of the urine persists, and has reference, now, to the complication by which the original disease has been superseded.

Sometimes, but rarely, measles are complicated with anasarca. Cases of this kind are of too infrequent occurrence to enable us to state what would be the composition of the urine under such circumstances. We may remark, however, that in three cases of measles complicated with anasarca, occurring at the Children's Hospital, Paris, not a trace of albumen could be detected in the urine. These cases recovered.

C. SCARLATINA.

In this, as in measles, the urine may present very different appearances, according to the stage of the disease, its severity, and complications.

SCARLATINA SIMPLEX.—In this form of the affection, the urine assumes the febrile characteristics in the highest degree. It is scanty, high-coloured, strongly acid, and not unfrequently deposits a sediment. These properties of the urine exist from the very onset of the disease, they persist during the eruptive stage, and diminish only when the fever itself begins to disappear, and the period of desquamation and convalescence to approach. As in typhoid fever and measles, the urine in scarlet fever sometimes contains a small quantity of albumen; its presence, however, is generally but temporary, and requires no special notice.

Blood is not found in the urine of uncomplicated scarlatina.

In scarlatina simplex, the period of convalescence is not marked by any appearances on the part of the urine, different from those observed during convalescence from other acute diseases.

SCARLATINA WITH COMPLICATION.—*Angina.*—Cases of this description are of daily occurrence, and the urine presents the ordinary febrile characteristics.

Nervous Symptoms.—They merely render the febrile qualities of the urine still more apparent.

Hæmorrhage.—Hæmorrhagic scarlatina, or that in which effusion of blood takes place from different parts of the body, is a rare disease. In those cases which have been made the subject of special observation, there was, almost always, coexistent hæmaturia, and a small quantity of albumen was likewise found in the urine.

Inflammations.—Their influence, combined with that of the original disease, renders the febrile character of the urine still more distinct.

Bright's Disease.—This may arise at two very different periods of scarlet fever. First, in an acute form, during the eruptive period, and previous to the appearance of dropsical symptoms. In such cases, the disease is often of great severity, and may rapidly prove fatal. In an instance which we have elsewhere recorded, and where death took place in three days, the urine was scanty, high-coloured, strongly acid, and contained a large amount of albumen.

As a rule, however, it is only during convalescence that scarlatina is complicated with albuminous urine and dropsical symptoms. We shall proceed to consider this latter complication.

Dropsy.—During the desquamative stage of scarlet fever, two species of dropsy may develope themselves.

1. Dropsy with non-albuminous urine.
2. Dropsy with albuminous urine.

First Variety.—*Dropsy, with non-albuminous urine.*—This form is by no means rare; it was long thought to be due to the influence of cold, and to the modifications produced by the desquamation of the skin, upon the cutaneous exhalation. According to our own researches, however, it would appear to be dependent upon a modification of the blood. This modification consisting in a diminished proportion of the albumen of the serum.

Second Variety.—*Dropsy with albuminous urine.*—Of this there are two kinds; one of which is due to the presence of Bright's disease; and another, which simulates this disease, although it, properly speaking, belongs to the first variety of dropsy. This requires some explanation.

Anasarca depending upon a diminished proportion of the albumen of the blood, may occur as a complication of scarlet fever, without the co-existence of Bright's kidney; and yet it may determine the presence of albumen in the urine in the following manner, viz., by the dropsy becoming general, and infiltrating various internal organs, among others, the kidneys. In this way, a true renal œdema may be produced, which, when once fully developed, almost invariably determines the presence in the urine, of a small but variable amount of albumen.

The presence of this albumen in the urine is a remarkable occurrence, and may always be explained as above, provided we bear in mind the following circumstances, which serve moreover to distinguish it from the albuminuria produced by Bright's disease.

In this latter affection, the albumen appears either simultaneously with, or previous to, the occurrence of dropsical symptoms; its quantity is generally considerable, and it is accompanied by a marked decrease of all the chief constituents of the urine, more especially of the urea. In œdema of the kidney, the dropsy precedes the appearance of albumen in the urine; the amount of albumen, moreover, is always trifling, nor is it attended with any particular modification of the remaining elements of the urine.

D. VARIOLA.

During the prodromic period of small-pox, the urine generally assumes the febrile character; it is scanty, high coloured, strongly acid, of high specific gravity, and occasionally deposits a sediment.

During the eruption, the urine retains these same characteristics.

After the eruption, the urine varies according as the disease has been varioloid or variola.

In varioloid, the urine regains its natural qualities as the period of desquamation approaches; this process commences from the moment when the febrile symptoms have ceased.

During the suppurative stage of variola, the urine still retains its febrile characters. Occasionally, a small amount of albumen may be present during the period of desquamation. It is not uncommon, when the disease has been very severe, to find the urine retaining its febrile characteristics for a considerable length of time.

In other cases, the urine rapidly assumes the anæmic character, as soon as the febrile symptoms have abated.

E. INTERMITTENT FEVER.

We shall consider the urine:

1. During the intermission;
2. During the paroxysm;

3. In each of the three phases which, taken together, constitute a paroxysm of ague.

1. *During the intermission*, the urine deviates from its natural condition, in proportion as the paroxysms are protracted and of frequent occurrence; it then presents the ordinary characteristics of febrile urine. These characteristics persist even during the intermission, when the fever occurs as a complication, or when there is not complete apyrexia.

2. *During the paroxysm.*—In many cases the urine, during the paroxysm, retains the characteristics which it presented during the intermission. Of twenty-two cases which we have elsewhere recorded, the urine in sixteen did not differ much during the three different stages of the paroxysm: in other words, that passed during the cold stage bore a close resemblance to that passed during the hot and sweating stages. In these sixteen cases, the urine excreted during each stage of the paroxysm resembled that passed during the intermission (*i.e.* in seven cases it was natural and in nine febrile). In the six remaining cases it deposited a sediment towards the close of the paroxysm. These deposits occurred either spontaneously, or on the addition of a drop or two of nitric acid.

The above facts do not confirm the opinion generally received, relative to the qualities of the urine during a paroxysm of intermittent fever. It is said to be pale and transparent during the cold stage, to become darker in colour during the hot stage, and, at the close of the sweating stage, to deposit a brick-red sediment, supposed to be one of the characteristics of intermittent fever.

This latter phenomenon may undoubtedly occur, since we have noticed it in six out of twenty-two cases. As for the nature of the deposits, they are composed, like those of acid urine in general, of uric acid and acid urates.

SECOND CLASS OF DISEASES.—THE PHLEGMASIÆ.

The chemical composition of the urine in the phlegmasiæ, affords an interesting subject of investigation, as it is undoubtedly in this class of diseases that it is least liable to variation, whether the affection be mild or severe, of long or short duration.

The characteristics of the urine in the phlegmasiæ may be summed up in a few lines, viz., febrile in the highest degree; at one time, high coloured, strongly acid, and of high specific gravity; at another, depositing a sediment, either spontaneously, or upon the addition of a drop of nitric acid; and occasionally containing a small quantity of albumen, but only for a short time.

This variety of urine lasts from the commencement of the disease, until all febrile symptoms have disappeared.

As types of the phlegmasiæ in general, we shall select pneumonia, pleurisy, and acute articular rheumatism.

A. PNEUMONIA.

When pneumonia attacks an individual of robust constitution and hitherto in good health, the urine becomes febrile, scanty, high-coloured, etc. These characters are most marked at the period when the disease has acquired its greatest intensity; as this declines, the urine gradually regains its normal appearance, and it rarely retains its febrile properties when the pneumonia has reached the stage of resolution.

The febrile urine of pneumonia may be one or other of the three varieties previously mentioned: 1. Ordinary febrile urine: this is generally the case; 2. Febrile urine, with some preexisting cause of debility; 3. Febrile urine, with a normal proportion of water: this indicates the comparatively mild nature of the attack, and the absence of a severe febrile condition of the system.

During convalescence, the urine at one time may present nothing unusual; at another, it may be pale, anæmic, and of low specific gravity.

When pneumonia is complicated with some other inflammation, the febrile qualities of the urine are still more strongly marked.

Pneumonia is one of those diseases in which the colouring matter of the urine undergoes the greatest increase, the fluid itself sometimes appearing of a deep mahogany colour.

Deposits of uric acid are very common, as in all acid febrile urine.

Of twenty-one cases of pneumonia in which the urine was carefully examined, there were nine in which a small quantity of albumen was found. Its presence, however, was but transitory: occurring sometimes at the commencement, sometimes at the close, and sometimes at the height of the disease, but never throughout its whole course.

B. PLEURISY.

In acute pleurisy, with severe and persistent febrile symptoms, the urine usually presents the same modifications as in pneumonia. It is febrile, scanty, high-coloured, of high specific gravity, frequently deposits a sediment, and occasionally contains a small amount of albumen. As resolution approaches and the fever abates, the urine gradually regains its normal characteristics. It may, however, in some cases, retain its dark colour, turbid appearance, and sedimentary deposit for a considerable length of time. In others, on the contrary, and especially if the patients have been subjected to copious bleeding, it may assume the anæmic type, previous even to the establishment of convalescence.

When effusion has taken place insidiously, without any evidence of an acute stage, the urine may either be natural in quality, or present the ordinary characters of febrile urine. The latter occurs in cases where, in spite of the chronicity of the disease, there are febrile symptoms; the former, in those where such symptoms are wanting; or where, along with the existence of fever, an asthenic condition has rapidly supervened.

C. ACUTE ARTICULAR RHEUMATISM.

When too copious bleedings have not been practised, the urine in this disease presents the febrile character. Its quantity is diminished, and it assumes a deep red hue. In fact, this is one of those diseases in which the colour of the urine is most marked; its specific gravity is increased, and deposits of uric acid are formed, often of a brick-red colour.

In convalescence from acute rheumatism, if the patient has been much debilitated, and presents an anæmic appearance, with blowing murmur in the carotids, the urine will likewise assume an anæmic type. In opposite circumstances it will regain its ordinary condition.

During the fever, one or two blood-lettings may temporarily render the urine anæmic; but should they be repeated, and the patient be much weakened thereby, the urine may assume the anæmic character, and retain it moreover, during the persistence of the febrile symptoms.

When these symptoms, however, have disappeared, nothing is more common than to notice an anæmic appearance of the urine, as a consequence of free and copious venesection. Of eighteen cases reported elsewhere, there were seven in which albumen was found in the urine during the febrile period; its appearance there being accidental and transitory. In five of these cases, however, it lasted for several days.*

During convalescence, the urine sometimes regains its normal condition; at others, it becomes anæmic.

The three examples just quoted, respecting the condition of the urine in the phlegmasiæ, serve to illustrate the chief characteristics of this fluid. In the work formerly mentioned,* may be found numerous examples of the phlegmasiæ, in which the urine was carefully examined. Thus, in acute cynanche tonsillaris, gastritis, enteritis, dysentery, bronchitis, erysipelas of the face, hepatitis, acute nephritis, etc. On these we do not deem it necessary to dwell.

THIRD CLASS OF DISEASES.—HÆMORRHAGES.

The condition of the urine in hæmorrhage is somewhat singular, inasmuch as the modifications which it undergoes are almost always identical. Thus, during the hæmorrhage or immediately after, the urine assumes the true febrile type, which is well marked in proportion to the loss of blood. In critical or scanty hæmorrhage, this modification of the urine takes place in a much less degree.

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* *Séméiotique des urines*, par A. Becquerel.

After the hæmorrhage, on the contrary, and more especially if it have been profuse, the patient almost always becomes, to a certain degree, anæmic, and this condition of the system is participated in by the urine; in other words, it also becomes anæmic.

In profuse epistaxis, hæmoptysis, and hæmatemesis, we may readily trace these modifications of the urine, which indicate, on the one hand, the general disturbance of the system during the hæmorrhage, and, on the other, the anæmic condition by which it is followed.

There is so little variation in the modifications of the urine, resulting from hæmorrhage, that we do not consider it necessary to enter into further details respecting them. We must not, however, pass over the subject of hæmaturia without a short notice.

Hæmaturia.—Hæmaturia may be a symptom of several very different conditions of one or other portion of the urinary apparatus. It may be the result of external violence, or of various forms of degeneration. It may be one of the manifestations of some condition of the system, characterized by a general hæmorrhagic tendency; such, for instance, as certain malignant forms of fever, measles, scarlatina, variola, scurvy, and purpura hæmorrhagica.

Hæmaturia may be idiopathic, and constitute in itself the sole disease: in such cases, the blood may come from the kidneys, ureters, bladder, or urethra.

In these different cases, the modification of the urine remains nevertheless the same; it consists simply in the presence of blood in the liquid. The consequences resulting therefrom, have already been treated of in a previous section.

FOURTH CLASS OF DISEASES.—DROPSIES AND FLUXES.

A. DROPSIES.

Dropsy is usually symptomatic, either of an alteration in the solids, or of some modification in the composition of the blood.

Dropsy symptomatic of a mechanical obstacle to the circulation.—This form of dropsy is generally the result, either of cardiac disease, of venous obstruction and obliteration, or of disease of the liver. We shall treat of these individually, hereafter.

Dropsy symptomatic of some modification of the blood.—This modification consists, for the most part, of a decrease on the part of the albumen. It may arise from various causes, referrible to two heads. The *first* comprises those which depend upon a decrease of the albumen of the blood, produced by the escape of a certain amount of this principle along with the urine. The *second* comprises those cases in which decrease of the albumen occurs, without its escape by the urine. Various causes may contribute to this result: thus, profuse hæmorrhages, prolonged discharges, habitual diarrhœa, marsh poison, etc., etc. In this form of dropsy by anæmia, properly so called, the character of the urine varies but little,—it belongs, in fact, to one or other variety of the anæmic type, as previously described. Should the patient, however, be attacked by feverish symptoms, the second variety of febrile urine will be the result.

B. FLUXES.

Sweats.—Whenever an individual has been the subject of profuse perspirations, from whatever cause, the urine presents the febrile character in the highest degree. It is generally very scanty, of high specific gravity, strongly acid, dark coloured, and almost always deposits a sediment.

Biliary Flux; Salivary Flux.—We possess but little information respecting the condition of the urine in these cases.

Urinary Flux.—Of this there are three forms: polydipsia, polyuria, and diabetes. It need scarcely be stated that, in these diseases, an examination of the urine is of the utmost importance.

Polydipsia.—This is a disease entirely constituted by an aberration of the sense of thirst, which is, for the most part, greatly increased. The water swallowed by the individual is almost entirely eliminated by the kidneys. The solid matters of the urine, on the contrary, are but slightly increased in quantity, both by reason of the increased action of the kidneys, and of the unusual amount of water passing through them. Hence, the equilibrium between the proportion of water and that of the solid matters is destroyed. The amount of water is greatly increased, while the solid matters remain, for the most part, almost unchanged. The urine, therefore, presents the anæmic character, but it is pseudo-anæmic, and due to a rupture of the equilibrium just alluded to.

Polyuria.—This is a very different affection from polydipsia. It is a true urinary flux, to which the terms *non-saccharine diabetes* and *diabetes insipidus* have been applied. The watery portion of the urine is increased, as are, likewise, the solid matters, in the same proportion; so that if but one emission of urine be examined, it may appear to be perfectly natural. If, however, we examine the entire amount passed in twenty-four hours, it is easy to perceive that the modifications which it undergoes are those just mentioned; in other words, the urine is normal, but it is secreted in much larger quantity than usual.

Polyuria tends to increase the sense of thirst, but this is only a consecutive phenomenon, whilst, on the contrary, this increase is the primary symptom in polydipsia, and precedes the profuse secretion of urine. There is, moreover, another important difference between these two conditions, which is, that polydipsia may exercise no injurious influence upon the general health. It merely produces the necessity of drinking and micturating very frequently. We have recently seen a man who, for twenty years, has been in the habit of drinking upwards of twenty quarts of water per diem, and who micturates in proportion, without the slightest injury to his general health. In polyuria, on the contrary, the aggregate of the solid matters of the urine being more or less increased, the patients become debilitated, emaciated, and the health suffers.

Polyuria is by no means a rare disease, but it has been, comparatively speaking, little investigated hitherto, and we would recommend it to the notice of observers. It may be idiopathic, and constitute the sole disease, or it may occur as a complication; sometimes it is a critical phenomenon, and this is not uncommon.

Diabetes Insipidus.—Some authors have described a diabetes insipidus. They allege, that the sugar contained in the urine possesses no saccharine flavour, but that the urine may nevertheless undergo fermentation.

This subject has been taken up by M. Bouchardat, and his researches have led him to the conclusion, that the substance regarded as tasteless sugar, is nothing but a compound of ordinary sugar, lactate of urea, lactate of soda, chloride of sodium, and extractive matters of the urine.

Saccharine Diabetes or Glucosuria.—The urine of diabetic persons is liable to considerable variations, depending upon the amount of ingesta.

Where an average amount of food is taken, it may present the following characteristics: 1. The quantity of urine may vary from twenty-eight to thirty-two pints; this, however, is somewhat rare.

The mean amount of urine secreted in diabetes is, according to M. Bouchardat, from about ten to sixteen pints: it may fall as low as six or eight pints, under the influence of rest and a restricted diet. In proportion as the disease approaches its fatal termination, does the quantity of urine generally decrease.

The quantity of urine is usually proportionate to the amount of liquid taken.

It varies in colour, but is often paler than healthy urine: its taste is saccharine, and its specific gravity much higher than usual, indicating a large amount of solid matters in solution. It may vary from 1020 to 1074.

Diabetic urine undergoes alcoholic fermentation.

Its transparency may be destroyed: 1. By mucus; and, 2. By deposits of uric acid; this latter circumstance, although rare, is occasionally met with.

Whenever we meet with pale urine, the specific gravity of which exceeds 1040, we may diagnose the presence of sugar.

Diabetic urine possesses, like a solution of grape sugar, the property of deviating to the right the ray of polarized light.

The amount of sugar contained in diabetic urine is liable to considerable variation. M. Bouchardat has met with specimens which contained from $\frac{1}{30}$ to $\frac{1}{7}$ of sugar. MM. Vauquelin and Ségalas have extracted upwards of $\frac{3}{4}$ of an ounce of sugar from $5\frac{1}{4}$ ounces of urine; and M. Mialhé, $7\frac{3}{4}$ drachms from $15\frac{5}{8}$ ounces of urine. Diabetic sugar is of the same nature as grape sugar.

A small quantity of albumen is occasionally met with; its presence coincides with a decrease in the quantity of the urine.

MM. Thénard and Dupuytren have regarded its presence in the urine as indicative of an approaching cure. Prout, on the contrary, asserts that it is only met with in the worst cases.

The amount of uric acid existing in diabetic urine, varies considerably; it sometimes, though rarely, forms a deposit (Bell, Rayer).

It has been erroneously asserted that the urea disappears from diabetic urine. The following process is employed to ascertain its presence by M. Bouchardat.

A specimen of diabetic urine having been evaporated and crystallized, the residuum is repeatedly treated with spirit of sulphuric æther: the solutions are then mixed and evaporated, and the residuum again dissolved in a sufficient quantity of water; the solution is then filtered, and on adding a few drops of nitric acid, crystals of nitrate of urea are obtained.

It is probable that the entire amount of urea is not thus obtained; a portion of it may remain, in spite of the repeated application of the sulphuric æther; moreover, a portion of it may be converted, during the latter part of the process, into carbonate of ammonia.

The quantity of urea contained in the urine of diabetic patients varies much in different cases, and even in the same case at different periods. This is due, according to M. Bouchardat, to the nature of the diet; being proportionate, as in health, to the quantity of nitrogenized matters introduced into the system.

Diabetic urine is almost always acid; this is due to the presence of free lactic acid.

The following analysis of diabetic urine is given by M. Bouchardat:

Water	835.55
Grape sugar	134.42
Urea	8.27
Albumen	1.40
Mucus	0.24
Lactic acid	6.38
Lactate of ammonia	
Extractive matter, soluble in alcohol	
Extractive matter, soluble in alcohol, insoluble in water	5.27
Salts	8.09

M. Bouchardat asserts, that whenever a diabetic patient has consented to adopt the regimen which he prescribes (abstinence from all food containing starch), the thirst has diminished, and the quantity of urine likewise. The proportion of sugar contained in the urine, likewise undergoes a great decrease, but it rarely disappears entirely; for although the urine may have lost its saccharine flavour, it still contains enough sugar to render the specific gravity higher than in health.

FIFTH GROUP OF DISEASES.—ORGANIC DISEASES.

As with the phlegmasiæ, we shall select merely the more ordinary organic affections, in order to examine the modifications of the urine to which they may give rise.

1. Organic diseases of the heart;
2. Tubercular disease of the lungs;
3. Cancer of the stomach;

4. Cancer of the liver;
5. Cirrhosis of the liver;
6. Bright's disease.

A. ORGANIC DISEASES OF THE HEART.

In this class of diseases, the modifications of the urine depend less on the different nature of the lesions of which the heart may be the seat, than upon the severity of the functional derangements to which these lesions have given rise. We may, therefore, here as before, consider these diseases as divisable into three stages:

First Stage.—Local and general symptoms but little marked; slight dyspnœa; the local signs chiefly indicate the existence of the cardiac lesion.

Second Stage.—Symptoms more marked; increase of dyspnœa and palpitation; commencing anasarca of the lower extremities.

Third Stage.—Severe dyspnœa and palpitation; semi-asphyxia; approaching death.

Certain additional circumstances may modify the urine. These are: 1. The occurrence of dropsy; 2. Hepatic complications; 3. Pulmonary emphysema; 4. Bright's disease; 5. Acute or chronic inflammatory complications.

In the *first stage* of cardiac disease, the urine may either remain unchanged, or it may diminish in quantity on certain days, without any appreciable cause, and become high-coloured, turbid, strongly acid, and sedimentary.

In the *second stage*, it is more rare to meet with a healthy condition of the urine; and the anæmic type is seldom observed; oftener, indeed, the urine is high-coloured, of high specific gravity, and strongly acid, etc.: lastly, it may present all the characteristics of true febrile urine.

In the *third stage*, the urine assumes the febrile character in the highest degree.

The complication of emphysema, of disease of the liver, or of an acute or chronic inflammation, increases still further the febrile qualities of the urine. In such cases, it is not uncommon to find the urine reduced to two or three ounces in the twenty-four hours, very turbid, strongly acid, and of high specific gravity.

Bright's disease is a not unfrequent complication, and often renders the diagnosis difficult, inasmuch as the cardiac disease may attract the observer's attention entirely, and mask the symptoms of the renal affection.

We see, for instance, an individual suffering from intense dyspnœa and violent palpitation; a physical examination of the heart indicates advanced disease of that organ; at the same time there is great infiltration of all the tissues. In such a case, we repeat, it is difficult to decide whether the patient is the subject of Bright's disease, occurring as a complication of cardiac lesion, or whether the infiltration depends merely upon the mechanical obstacle to the circulation. An examination of the urine can alone decide the question.

Four cases may here present themselves, each of which has its own signification:

1. The urine may be either normal or febrile, but without a trace of albumen. The kidneys are in this case healthy.

2. The urine is pale, feebly acid, and contains a considerable amount of albumen. This is the urine of Bright's disease, and the existence of the lesion is thus demonstrated.

3. The urine is healthy or febrile, and contains albumen, but in small quantity. This case is one of more difficult diagnosis than the preceding, as it indicates simple mechanical congestion of the kidney, produced under the influence of the obstacle to the circulation, existing within the heart; and it is the practitioner alone that can affirm, from the amount of albumen, that there is merely mechanical congestion of the kidney present, and not Bright's disease.

4. The urine may be febrile, and, at the same time, contain a large amount of albumen. In such a case it is tolerably certain that Bright's disease is present.

It is evident, therefore, that in some cases the diagnosis may be a question of much difficulty, inasmuch as it must be founded on the greater or less amount of albumen present in the urine.

It may be stated that, without the complication of Bright's kidney, it is very common, in the later stages of cardiac disease, to find albumen in the urine; its presence being due to simple mechanical congestion of the kidney.

The following statistical results, extracted from the work previously mentioned,* may serve to prove the truth of what has been here advanced.

Of thirty-one cases of cardiac disease, there were seven in the first stage, fifteen in the second, and nine in the third. In the first seven, not a trace of albumen could be detected in the urine, during the patients' stay in hospital.

Of the fifteen cases where the disease had reached its second stage, there were six in which the presence of albumen in the urine was observed, but only for a short time, and more especially during the first few days of the patients' residence in hospital, when the general symptoms had as yet undergone no alleviation.

Of the nine cases of advanced cardiac disease, there were four in which the urine contained albumen, and in each of these it appeared during the few days which preceded the fatal event; in other words, at the period when the symptoms had attained their greatest intensity, and when mechanical congestion of the kidney had taken place, as shewn at the autopsy.

Lastly, as we have before stated, the presence of albumen in the urine may be due to an œdema of the kidney, occurring under the influence of dropsical infiltration of the tissues in general.

B. TUBERCULAR DISEASE OF THE LUNGS.

The development of pulmonary tubercle may occur in connexion with three very different conditions of the system; it is easy, therefore, to foresee that under such circumstances the urine in this disease may present considerable variations.

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* *Séméiotique des urines.*

The circumstances capable of imparting different qualities to the urine are as follows: *a.* The amount of local disease; *b.* The degree of fever by which it is accompanied; *c.* The predominance of certain symptoms, such as dyspnœa; *d.* The occurrence of severe hæmoptysis, of colliquative diarrhœa, of profuse sweats; *e.* A pneumonic complication; and, lastly, the degree of constitutional debility produced by the disease itself.

In the majority of cases, where the disease has passed the first stage, we find the urine diminished in quantity, of high specific gravity, and dark coloured (febrile urine). This is not what might have been anticipated from the great debility into which the system is, for the most part, thrown by the deposition of tubercle in the lung. But in proportion as the disease progresses, there is set up a continuous febrile condition which imparts its peculiar characteristics to the urine. At the same time, the sweats, which towards morning terminate the febrile exacerbation, tend to deprive the urine of a portion of its water, and thus render its febrile qualities still more marked.

The diarrhœa of phthisis, associated as it is with ulcerative disease of the intestine, tends still further to increase the febrile characteristics of the urine, unless that by their extreme profuseness the alvine discharges have thrown the patient into a state of complete asthenia. In such cases the urine rapidly loses its febrile quality, and assumes the anæmic type.

In phthisical patients, the qualities of the urine are, to a certain extent, influenced by two classes of causes, which act in contrary directions, and of which one or the other predominates, according to the constitutional tendencies of the individual. One of these is the state of anæmia and debility accompanying the later stages of phthisis; the other is the fever with its attendant organic derangements, whether of the lungs or elsewhere. Experience shews, that from this antagonistic influence, the second variety of febrile urine is frequently produced. The fever and anæmia each tending to diminish the sum-total of the solid matters of the urine, its constituent elements are often at their minimum.

We learn, moreover, from observation, that in the most advanced stages of phthisis the anæmia influences the urine more than the fever. For further details relative to this subject, we would refer the reader to the work previously quoted, viz., *De la Séméiotique des urines.*

Albumen is occasionally met with in very small quantity in the urine of phthisical patients.

We must here be understood as altogether setting aside those cases in which tubercle of the lung is complicated with Bright's disease. We shall return to this subject hereafter.

Lastly, we may state, that in the third stage of pulmonary consumption, the urine in children becomes more frequently anæmic than in adults; and this in spite of a considerable amount of febrile excitement.

C. CANCER OF THE STOMACH.

In this disease the urine may present considerable variations. Sometimes it retains its physiological characteristics; at others it may assume the febrile or the anæmic type. These modifications may generally be attributed to the following circumstances:

When cancer of the stomach does not, up to a certain point, interfere with the process of digestion, and the system has not as yet undergone much deterioration, the urine is natural.

When gastric cancer is accompanied by severe local functional derangement, such as acute pain and frequent vomiting, the urine becomes febrile.

Lastly, when under the prolonged influence of the disease, of insufficient nourishment, and of repeated hæmatemesis, an anæmic condition of the system supervenes, the urine likewise presents the anæmic character.

It is not uncommon, in cases where the urine is febrile, to find it containing a small quantity of albumen; its appearance, however, is but transitory.

D. CANCER OF THE LIVER.

This disease is one of those in which the urine presents the febrile character in the very highest degree, and retains it, moreover, for the greatest length of time.

E. CIRRHOSIS OF THE LIVER.

At the commencement of the disease, more especially if chronic, the urine varies but little.

When jaundice co-exists, the urine assumes a saffron yellow colour, and contains a certain amount of biliary colouring matter. When cirrhosis reaches a more advanced stage, and gives rise to severe functional disorder, the changes in the urine are absolutely identical with those observed in cancer of the liver.

The following are the chief characteristics of the urine in cirrhosis of the liver:

a. The quantity is greatly diminished;

b. Its colour is a dark orange yellow, and often reddish;

c. Its specific gravity is increased;

d. It is strongly acid, and loaded with uric acid, which is precipitated either spontaneously, or upon the addition of a small quantity of nitric acid. This precipitate is usually of a bright colour, not unlike that of cinnabar.

Urine of this kind, occurring in connexion with cirrhosis of the liver, shews that the disease, whatever stage it may have reached, has given rise to functional derangement, irrespective of any complication.

The existence of gastric cancer, of pulmonary tubercle, or of organic disease of the heart, all of which may coincide with, and even precede, cirrhosis of the liver, in no way affect the aforesaid qualities of the urine.

Should a complication exist, such, for instance, as Bright's disease, two cases may present themselves:

1. If the cirrhosis has preceded the renal affection, and has already reached an advanced stage, the urine will present the characters mentioned above, and may contain a large amount of albumen.

2. If, on the contrary, the two diseases have been developed

simultaneously, the lesion of the kidney being always, in such a case, more advanced than that of the liver, the urine will present all the characteristics indicative of Bright's disease.

F. BRIGHT'S DISEASE.

1. *Changes occurring in the Urine.*—The changes which the urine may undergo in Bright's disease, are far from being always identical. Thus, it has been too generally asserted that the urea was always diminished in quantity. It is undoubtedly true, that, in some cases, this principle is less abundant than in health; but this arises from the anæmic quality of the urine, and not from the renal disease; we shall presently endeavour to demonstrate the truth of this proposition.

The urine in Bright's disease is modified: 1. By the presence of certain additional chemical elements; and 2. By a change in the proportion of those which it already contains.

a. By the presence of certain additional elements: 1. *Albumen.*—The presence of albumen in the urine is the invariable rule in Bright's disease, and it continues to be present until either the disease is cured, or death takes place. Its proportion varies much, according to the individual, and to the stage of the disease; and frequently, indeed, from day to day. In this respect, therefore, we are unable to speak positively, but we have ourselves seen it oscillate from between 30 and 45 grains to 150 grains and upwards, in the urine secreted during twenty-four hours.

The presence of albumen in acid urine may be recognized by its coagulating on the application of heat; in certain exceptional cases where, in spite of the acidity of the urine, the albumen (possibly from some special molecular condition) is not precipitated by ebullition, the addition of nitric acid is requisite. It is only by the employment of this latter agent that we are enabled to determine the coagulation of the albumen in alkaline urine.

To ascertain the amount of albumen contained in the urine, we take a given quantity of the latter, and apply nitric acid if it be alkaline, and heat if it be acid. It is then filtered, and the albumen which remains upon the filter is washed successively with water and alcohol; it is then carefully dried and weighed. The weight thus obtained being referred to that of the sum total of the urine.

The amount of albumen contained in the urine may be ascertained with still greater accuracy by means of the polarizing apparatus, or albuminometer, to which we have formerly alluded, when speaking of the albumen of the blood. We have made some experiments in this direction, and are thoroughly convinced of the accuracy of the procedure.

2. *Blood.*—The urine, in Bright's disease, frequently contains blood, but in very small quantities. It occurs, for the most part, at the commencement of the disease, more especially if acute. It may occasionally, though very rarely, be met with throughout its whole course. The blood thus existing in the urine, rarely retains its natural properties; it is almost always changed, and communicates a brown or reddish-brown colour to the urine, sometimes resembling the washings of meat. When examined under the microscope, the blood globules are rarely found perfect; they are generally irregular, serrated, and partly destroyed; and these changes may be traced up to their complete destruction. Besides blood globules, the microscope not infrequently reveals a species of detritus, or of amorphous matter, in all probability resulting from the effect of the urine upon the contained blood. The presence of this blood in the urine, more especially at the commencement of the disease, may be readily conceived, if we bear in mind, that the first stage of the renal affection consists of sanguineous congestion of the cortical substance, and, that in passing from the first to the second stage, the blood loses its colouring matter.

3. *Organic Detritus.*—In the urine of individuals affected with Bright's disease, we sometimes meet with an organic insoluble matter, the nature of which is undetermined; it appears, under the microscope, in the form of irregular amorphous fragments, of a brownish colour. The urine often contains a certain quantity of this substance during the whole course of

the disease.—Is this detritus, we might ask, composed of the colouring matter of the decomposed blood?

6. *Modifications occurring in the normal constituents of the urine.*—Putting out of the question, for the moment, those foreign matters of which we have just treated, and supposing them to have been separated from the urine, we find that this fluid, as regards composition, may be classed under one or other of the four principal divisions formerly established. In the majority of cases, it presents the anæmic character, but occasionally the febrile; not unfrequently it is alkaline, while sometimes it may be perfectly natural. We shall examine in succession, the cases in which these different varieties of the urine may be met with.

1. *Anæmic Urine.*—The urine, as we have before stated, is generally anæmic in Bright's disease, in other words, the chemical principles held in solution are all about equally diminished in point of quantity. The filtered fluid (the albumen having coagulated) is pale, clear, and of a greenish colour. Its specific gravity is low. Of twenty-two cases of Bright's disease, in which the urine was examined almost daily, the liquid in sixteen presented, during the whole course of the disease, with some rare exceptions, the anæmic character, and a low specific gravity, varying from 1006.300 to 1014.700. The mean being 1011.340. Deposits were not often met with. The acidity of the urine in these sixteen cases varied; its quantity did so likewise, but not to any great extent, differing, in fact, but little from that of health.

Analysis of the urine in these cases shews, that its chemical constituents are uniformly and equally diminished. We are not, therefore, surprised that a decrease of the urea should have been met with in connexion with Bright's disease, but we repeat, this is due to the anæmic character of the urine and not to the lesion of the kidney. This anæmic condition of the urine is, in the majority of cases, easily explained; since, as we shall presently prove, the blood of individuals affected with Bright's disease, is deficient in albumen; they are debilitated, and in an actual condition of albuminuric anæmia; itself the real cause of the dropsical phenomena from which they suffer.

Febrile Urine.—In Bright's disease, the first and second variety of febrile urine may be both met with ; it is generally more scanty than usual, dark coloured and acid, of higher specific gravity in the first than in the second variety, etc., and deposits a sediment, which is, for the most part, composed of uric acid.

The causes giving rise to these varieties of febrile urine are the following complications : viz., the various phlegmasiæ which so frequently occur in persons labouring under Bright's disease, advanced cardiac disease, cirrhosis of the liver, and extensive emphysema. If the complication be removed, or much amelioration produced, the urine rapidly regains its anæmic character. Hence it may be seen, that the renal lesion does not prevent the urine from being subject to the laws previously established. Of the twenty-two cases just quoted, the urine, in four, presented the febrile characteristics ; these continued up to the close in two ; in two others, they became subsequently anæmic ; in one case from amelioration of the symptoms, in the other from the fact of a concomitant inflammation having been cured. The mean specific gravity of the urine, in these four cases, was 1023.520, and it frequently contained deposits of uric acid.

3. *Alkaline Urine.*—In some cases of Bright's disease the urine becomes alkaline, and deposits sediments which are composed of phosphate and carbonate of lime, and of ammoniaco-magnesian phosphates. Alkaline urine, under such circumstances, almost always contains a large amount of carbonic acid, in combination with different bases. This acid results from decomposition of the urea. In a quantitative analysis, quoted in the annexed table, the proportion of urea was found to be greatly diminished, and this readily explained the large amount of carbonic acid afforded by the urine. Hence the decrease of the urea in such cases, viz., by its conversion into carbonate of ammonia. There is no absolute decrease, however, as has been often asserted. In two of the twenty-two cases

already quoted, the urine was alkaline, contained a sediment, and was highly charged with carbonic acid during the whole course of the disease. Urine of this kind is generally more viscid than usual, owing to the reaction of the ammoniacal product upon the small quantity of mucus which it contains. Pus is rarely met with.

4. *Urine differing but little from that of health, with reference to the proportion of its chemical constituents.*—Urine of this kind is, as a rule, only met with at the commencement of the disease, when the patient has not as yet been debilitated and exhausted by the impoverishment of the blood and the escape of the albumen with the urine. In two cases, we found the urine to be almost natural; it subsequently became anæmic.

Such are the different characteristics presented by the urine in Bright's disease; in the subjoined table will be found the detailed analysis of the renal secretion, in five cases of this affection.

Analysis of the Urine in Bright's Disease.

Disease.	Observations relative to the disease.	Qualities of the urine.	Specific gravity.	Amount of urine.	Amount of water.	Sum of solid matters.	Urea.	Uric acid.	Inorganic salts.	Organic matters.	Albumen.
Simple form of Bright's disease.	*First Analysis.* Slight fever: acute form of the disease.	Colour, yellowish green, somewhat dirty, strongly acid, and containing a little mucus......	1016.580	816.20	787.576	28.624	9.495	0.264	5.385	3.763	9.715
	Second Analysis. The disease has assumed the chronic form; apyrexia.	Colour, a more transparent green, acid	1010.080	1030.750	1011.610	19.140	6.520	0.616	4.277	5.097	2.630
Ditto ditto	In a man in whom the disease was nearly cured, the urine contains less albumen than formerly. He was eventually cured.	Acid, of transparent greenish colour, contains a small quantity of mucus	1007.560	1830.400	1807.400	23.046	11.648	0.583	4.615	5.984	0.208
Bright's disease, with polydipsia.	A man affected with polydipsia, œdema of the legs, and ascites; the symptoms were relieved by the use of tincture of cantharides, horse-radish, and vapour baths.	Urine transparent and alkaline, slight whitish deposit, effervesces strongly with acids	1008.400	2291.200	2259.444	31.756	4.272	0.448	6.608	12.620	7.808
Bright's disease, with tubercular disease of the lungs.	Occurring in an intemperate individual. There was anasarca, with slight ascites, and a tendency to polydipsia.	Urine slightly acid, pale, transparent, and abundant	1005.460	3117.500	3083.405	34.095	11.910	0.795	5.208	9.952	8.170
Bright's disease, 1st stage.	No infiltration, nor any dropsical symptom whatever.	Urine tinged with blood, containing likewise a little uric acid; strongly acid	1012.600	741.25	722.320	18.930	5.784	0.347	3.800	4.454	4.545
		Mean......	1010.080	..	..	25.931	8.322	0.509	5.159	6.643	..

SIXTH CLASS OF DISEASES.—DISEASES OF CERTAIN ORGANS.

Before terminating the history of the urine, we shall examine it somewhat closely:

1. In some diseases of the brain, and in certain of the neuroses;
2. In puerperal diseases;
3. And lastly, in diseases of the kidney. Upon these we shall lay special stress.

A. ORGANIC DISEASES OF THE BRAIN:

CEREBRAL HÆMORRHAGES—ENCEPHALITIS—ACUTE SOFTENING.

The modifications of the urine in these diseases, may be referred to certain general principles.

The following are the chief conclusions at which we have arrived:

In cerebral diseases of an acute character, and characterised by severe nervous symptoms, the urine, in general, assumes the febrile type.

Should the patient recover, with or without local paralysis, the urine regains its natural condition, provided the bladder be unaffected.

Should the disease be chronic, and have produced paralysis of the bladder, the urine becomes alkaline, turbid, loaded with phosphates and carbonate of lime, and often with ammoniaco-magnesian phosphate. In such cases, it almost always contains purulent mucus, and is voided involuntarily.

B. DISEASES OF THE SPINAL CORD.

These may be subdivided into two classes, as regards the condition of the urine.

In the first, there is no functional lesion of either the kidneys or the bladder.

In the second, the function of these organs is more or less deranged.

1. *Diseases of the spinal cord without functional derange-*

ment of the kidneys and bladder.—Of these, some, at their origin, may be included in the first category, but they subsequently pass into the second, since in proportion as diseases of the spinal cord progress, do the functions of the bladder become gradually deranged.

In cases belonging to the first class, the urine, for the most part, retains its natural condition, or at least varies but little. Thus, two patients, one thirty and the other sixty years of age, were affected with slight motor and sensary paralysis of the lower extremities; they could support themselves in the upright position, but with difficulty; the organic functions were unaffected, and the urine perfectly natural, although varying from day to day, on account of the differences in the proportion of water.

The urine in these cases was acid, and contained somewhat more mucus than usual.

2. *Diseases of the spinal cord with functional derangements of the bladder.*—These derangements consist: 1. In a retention of urine: a rare and accidental phenomenon; 2. In an involuntary discharge of the contents of the bladder, which, on the contrary, is of very frequent occurrence: five individuals, whose history is detailed in the work often before quoted (*Séméiotique des urines*), suffered from this involuntary emission of urine.

In such cases, the urine always undergoes certain changes: it becomes alkaline, of a dirty pale yellow colour, and of average specific gravity. In other cases, it becomes more transparent, and the specific gravity falls.

Urine of this kind almost invariably holds in suspension or solution, some or all of the following principles:

Opaque mucus, muco-pus, or true pus;

A small quantity of albumen, especially in the latter case;

Ammoniaco-magnesian phosphate;

Pulverizable phosphate and carbonate of lime;

A pellicle often forms on the surface of the urine, indicating the crystallization of the salts. This process is often favoured by the mucus existing in the urine.

It might here be asked, is such urine as this the product of vitiated renal secretion, or is it due to that chronic inflammation of the bladder, which so frequently complicates disease of the spinal cord in its later stages?

The question does not admit of being readily answered: for if we bear in mind that the paralyzed condition of the bladder renders the evacuation of urine instantaneous, we should be led, *à priori*, to assert, that this species of urine is actually the result of renal secretion. Undoubtedly this is sometimes the case; and in diseases of the cord, the kidneys have not unfrequently been found in a state of inflammation, degeneration, etc.; this, however, is not always the case, and we must therefore adopt some other view.

In the first place, how is the involuntary emission of urine produced? It is not immediate, as might be supposed; the bladder must first be filled and distended, when an overflow of urine follows. The secretion of the kidneys, therefore, remains in the bladder for a certain space of time, and hence arises, for the most part, the spontaneous change which it undergoes. Some authorities deny that it can thus take place. Admitting this, however, for the moment, it cannot be denied, that the prolonged and repeated retention of urine in the bladder, at last produces inflammation of its mucous membrane. When once this condition has been set up, a secretion of pus or muco-pus ensues, which, by its admixture with the urine, rapidly gives rise to the changes usually observed in such cases. This condition of the urine, therefore, is produced by the reciprocal influence—1. Of the liquid which stagnates in the bladder, and there acquires still more irritating qualities; and 2. Of the bladder, which, becoming gradually inflamed under the influence of this repeated irritation, furnishes an abundant secretion of pus. Chronic cystitis exercises a remarkable influence over the colour and specific gravity of the urine. When this affection, whether idiopathic or symptomatic of spinal disease, occurs in a well-marked form, the urine, mingling with the pus, becomes less dense and more transparent. The kidneys are often inflamed in cases where the bladder is thus affected, and hence they may at last secrete true purulent, alkaline urine. This inflammation is often due to an extension of the disease, by continuity, from the bladder.

C. HYSTERIA AND HYSTERIC AFFECTIONS.

Under this title we comprehend a certain number of the neuroses, of which the characteristic feature consists in the occurrence of *hysteric* or *nervous* attacks.

In such cases, the following conditions of the urine may be met with:

1. It remains unchanged.
2. Its quantity decreases for a short time. There is temporary febrile urine. Decrease in quantity, dark colour, high specific gravity, and even a deposit.
3. There is a momentary increase in point of quantity, *i.e.* a urinary flux: the urine being copious, pale, transparent, limpid, and of low specific gravity.

It is difficult to explain the production of these different conditions of the urine, under the influence of apparently similar causes. We might compare, however, what occurs here, with that which takes place in regard to the liver: for under the influence of some strong moral emotion, we at one time find the biliary secretion suppressed and jaundice produced; while at another, the bile is increased in quantity, and bilious diarrhœa is the result.

During the interval between the attacks, the urine regains its normal character, provided that the nervous symptoms have entirely disappeared. Should they, however, persist, we notice a continuance of the changes, produced in the urine by the previous attack.

In the various forms of neuralgia, and in hemicrania, the modifications of the urine are similar to those observed in hysteria, and each of the three varieties previously mentioned, may be noticed. We should state, however, that the second variety, viz., febrile urine, is by far the most common.

D. PUERPERAL DISEASES.

1. *Pregnancy.*—During pregnancy the general health of the female is liable to much variation, and the urine consequently may present very different qualities in accordance with the same.

It most frequently retains its normal condition; this happens whenever the female enjoys good health.

If, on the contrary, accidents or complications arise, the urine may readily assume the febrile type. During the latter stages of pregnancy it frequently becomes anæmic.

In some pregnant women, there is an abundant mucous discharge from the vagina; in such a case we notice numerous opaque clouds floating in the urine, and occasionally a small quantity of albumen may be detected.

A complication may likewise exist, which has of late been much investigated, viz., dropsy.

Four varieties of dropsy may arise during pregnancy:

1. Mechanical dropsy of the lower extremities, produced by the pressure, on the inferior vena cava and iliac veins, of the gravid uterus. In this case the urine is either natural, or corresponds with the general condition of the individual, whether febrile or anæmic.

2. The dropsy may be due to Bright's disease of the kidney, occurring as a complication; or,

3. To simple albuminuria without such disease.

It would appear impossible to discriminate between these two cases. Both give rise to similar modifications of the urine; both cause the appearance of about an equal amount of albumen in the urine; both act by diminishing the proportion of albumen contained in the blood, and thus producing infiltration of serum into the cellular tissue and serous cavities; lastly, both give rise to similar predispositions, viz., to convulsions and puerperal fever.

4. The dropsy may be due to a diminished proportion of the albumen of the blood. In such cases no albumen is found in the urine, which for the most part presents the anæmic character.

Various attempts have been made, at different times, to discover certain changes in the urine which might contribute to the diagnosis of pregnancy. The majority of these have been unsuccessful. One of them, however, has acquired a certain amount of notoriety; it is that supposed to have been discovered by Nauché.

According to this author, there exists in the urine a peculiar substance, to which he gives the name of *kiestine*, and which, in pregnant women, forms, as the urine cools, a pellicle upon its surface.

This discovery is a pure illusion, due, in all probability, to the following cause: in pregnant women the urine generally contains a certain quantity of mucus, rendering the decomposition of this liquid more easy than usual; now it is not unlikely that the presence of this mucus, and its influence upon the decomposition of the urine, may have led Nauché to regard as a special production, the thin pellicle of ammoniaco-magnesian phosphate deposited on the surface of the liquid, during the process of decomposition.

2. *Parturition.*—Before examining the influence exercised by this important physiological act upon the condition of the urine, it may not be amiss to dwell somewhat upon the lochial discharge, which almost always mingles in small quantities with the urine, and imparts to it certain special characters.

Immediately after delivery, the occurrence of a sero-sanguineous discharge from the uterus and vagina is a constant fact. At first, the blood is almost pure, but watery; somewhat later, it becomes still more so, and the liquid which escapes is the serum of the blood, merely tinged by a few suspended globules.

This serosity is analogous, in point of composition, to that of the blood; it may be mingled with the urine, in various proportions, according to the condition of the female, at the moment when the act of micturition is performed. This condition is subject to such variations, that here, as in leucorrhœa, not a trace of the discharge can be detected in the urine at one time, while at another it may exist in more or less abundance.

When this serosity is mingled with the urine, it renders it turbid, and causes the formation of a semi-opaque cloud, of a somewhat reddish tinge. The microscope demonstrates the presence of numerous blood globules; while nitric acid and heat precipitate a certain amount of albumen. This is what we find during the first twenty-four or thirty-six hours succeeding delivery.

Subsequently, the sero-sanguineous nature of the discharge gradually disappears, and the true characteristics of the lochia become manifest. What, then, we might ask, is this new fluid? It partakes, in many respects, of the nature of the leucorrhœal discharge; and we cannot define it better, than by saying that it is a mixture of albuminous serosity, with semi-opaque, turbid mucus. It participates, therefore, in the qualities of these substances, in affording albumen on the application of heat and nitric acid, and in presenting numerous globules of mucus under the microscope.

This fluid has a characteristic odour, *sui generis*, which it is difficult to define, but which is excessively nauseous. The lochial discharge itself may remain perfectly distinct from the urine, but is, however, more generally mixed up with it in various proportions; when this is the case, the urine becomes turbid, holding albumen in solution, and semi-opaque clouds in suspension. This discharge continues during the milk fever, and for a short time after; it ceases on the third or fourth day after the departure of the fever.

During the interval which elapses between the act of parturition and the subsequent milk fever, a period varying from twenty-four to seventy-two hours, several circumstances may arise.

1. The general health of the female may be affected; the labour, for instance, may have been protracted and difficult; artificial means of delivery may have been found necessary. The patient may be in much pain still, and fever may even be present. Under such circumstances, the urine may assume the febrile character; the second variety being not unfrequent, owing to the existence of certain debilitating causes (the result

of parturition), which diminish, still further, the sum total of solid matters held in solution.

2. Even should all the above conditions not have been present, it most generally happens, that the patients are debilitated, and that the urine assumes the anæmic character.

3. *Milk Fever.*—This commences, for the most part, from twenty-four to thirty-six hours or more after delivery. It is often accompanied by profuse perspiration, which may be regarded as exercising a certain amount of influence upon the urine.

The almost invariable effect of milk fever, is to produce one or other of the three varieties of febrile urine, more especially the two first; the third being comparatively rare. The urine, putting aside the lochial matter which it may chance to contain, is diminished in quantity, it becomes more acid, darker in colour, of higher specific gravity, and frequently deposits uric acid, either spontaneously, or on the addition of nitric acid. It is rare for the urine not to assume the febrile character during the milk fever; the existence of anæmic urine, under such circumstances, would indicate great debility and exhaustion on the part of the female. It may, however, occasionally be met with.

4. *Puerperal Fever.*—The characteristic feature of the urine in puerperal fever, is to present the febrile type in its most marked form. It often contains, moreover, a certain amount of albumen; this invariably occurs when the complication in question attacks a female who has suffered from dropsical symptoms during pregnancy. We have already explained the reason of this phenomenon.

E. DISEASES OF THE KIDNEYS, URETERS, AND BLADDER.

1. *Acute Nephritis.*—We first presuppose the absence of inflammatory action in the mucous membrane of the urinary passages.

According to M. Rayer, the urine, in this disease, undergoes the following changes:

1. The quantity secreted is much diminished, and may even be suppressed, if both kidneys are affected;

2. It contains a certain quantity of albumen or blood;

3. It is slightly acid, neutral, or alkaline;

4. It may contain pus; this is rare, and occurs when an abscess communicates with the pelvis of the kidney: or, what is more common, when nephritis is complicated with inflammation of the lining membrane of the ureters and bladder.

The above propositions are sound and warrantable.

2. *Chronic Nephritis.*—The following are the results arrived at by M. Rayer:

In simple chronic nephritis, without inflammation of either the bladder, prostrate gland, or urethra, the urine rarely contains albumen or blood; but an excess of mucus is frequently observed. Pus may likewise be met with, when the disease is complicated with chronic inflammation of the pelvis of the kidneys, or of other portions of the mucous membrane of the urinary apparatus. The urine is often alkaline.

3. *Inflammation of the pelvis of the kidney and ureters.*—The effect of these diseases is, to determine the presence, in the urine, of a variable amount of pus. The urine, after admixture with this foreign substance, sometimes retains its acidity, but more commonly it hastens the decomposition of the urea into sub-carbonate of ammonia, and renders the urine alkaline. It presents, in fact, all the characteristic appearances already noticed as resulting from the presence of pus, and sometimes contains blood: of the effects of this last upon the urine, we have elsewhere treated.

M. Rayer has given to this disease the name of pyelitis, and has devoted to it several interesting chapters in the third volume of his treatise *On the Diseases of the Kidney;* one of these treats of the history of calculous pyelitis, or calculous nephritis of previous authors, as follows:

4. *Calculous Pyelitis.*—This disease, affecting the calyx, pelvis of the kidney, and ureters, frequently complicates disease of the kidney itself (pyelo-calculous nephritis), and is due to the presence of either gravel or calculi. The following

are the modifications of the urine, to which this particular inflammation gives rise.

M. Rayer begins by admitting five stages of the disease.

First Stage.—Nephritic colic, suppression of urine, or escape of merely a few drops, of a deep red colour.

Second Stage.—Urine less highly coloured, containing mucus and often blood. These two substances are often mingled with the uric acid and salts.

The urine may likewise contain gravel; in such a case, we notice reddish rhomboidal crystals of uric acid, and the urine itself is strongly acid. It is, on the contrary, alkaline, if the calculi are phosphatic.

Third Stage (purulent secretion without renal tumour).—Urine sometimes bloody, more frequently white and turbid; deposits due either to pus alone, or to its admixture with the salts.

Fourth Stage (purulent urine with renal tumour).—This tumour is owing to the accumulation of pus in the distended pelvis and calices of the kidney. The urine is purulent and bloody, but liable to considerable variations. At one emission it may be turbid and loaded with pus, while at another it may present the usual appearances of health. This difference depends upon the admixture or non-admixture of the pus with the urine.

This latter fluid almost always contains a larger amount of albumen than can be explained by the presence of the pus. During this fourth stage, retention of urine may occur.

Fifth Stage.—Atrophy of the kidney, without purulent secretion.

5. *Acute Cystitis.*—The effect of acute cystitis is to produce a marked increase of the mucus of the urine, and even to convert it into pus, with results similar to those which take place in the preceding cases. The quantity of mucus, however, is never so great as in chronic cystitis.

6. *Chronic Cystitis.*—This constitutes the very frequent disease, to which the term *catarrh of the bladder* has been applied. It may arise from various causes, upon which it is not our province here to dwell.

We have repeatedly examined the urine in this disease; and the modifications which it undergoes are as follows:

a. The quantity varies, differing but little, however, from the standard of health.

b. The specific gravity varies greatly, by reason of the very different proportions of water which the urine may contain.

c. Its colour is pale, but can scarcely be well ascertained without filtration.

d. It is alkaline, and has an ammoniacal urinous odour.

e. Its transparency is affected by a layer of mucus, varying both in quality and quantity; in some cases it is perfectly clear; this, however, is rare; for the most part, it is turbid, semi-opaque, and exhibits, under the microscope, mucus or pus globules. The urine is more viscid than natural, owing to the reaction of the sub-carbonate of ammonia upon the pus and mucus.

The transparency of the urine is often affected by the precipitates which constitute the usual deposits of alkaline urine: viz., phosphate of lime, sub-carbonate of lime and magnesia, ammoniaco-magnesian phosphates.

This variety of urine is generally turbid, of a dirty appearance and semi-opaque; it sometimes contains a small quantity of albumen, but this is by no means constant. The addition of æther shews an increase of the fatty matter.

The urea is considerably diminished; from its conversion into sub-carbonate of ammonia, results the alkaline condition of the urine, and the secondary changes which it undergoes.

Lastly, in vesical catarrh, the urine always holds in solution a certain quantity of sub-carbonate of ammonia, derived, as we have just stated, from the decomposition of the urea. This is proved by adding to the urine a small quantity of some strong acid; violent effervescence takes place, and carbonic acid is evolved.

7. *Blenorrhagia.*—Simple blenorrhagia, whether acute or chronic, merely determines in the urine, the presence of a small quantity of muco-pus, which is sometimes precipitated in the form of flakes, and at others, in that of whitish filaments. It

is seldom sufficiently abundant to render the urine alkaline. When the discharge is profuse, it occasionally happens, that the morning urine contains more muco-pus than at other times, together with a small quantity of albumen. In such cases, the urine is less acid than usual.

8. *Retention of Urine.*—We shall here consider the symptom alone, irrespective of the numerous causes which may give rise to it. When retention of urine is but a temporary phenomenon, occurring for the first time, and lasting but a little while, its only effect is to cause a concentration of the urine, by reason of the absorption of a portion of its watery element.

In other respects, no important change occurs. It frequently, indeed, happens, that the urine is drawn off, in persons labouring under very different diseases, such as typhoid fever, puerperal fever, erysipelas of the face, etc., and in each of these it presents the ordinary characteristics of the particular affection from which the patient may be suffering.

In prolonged retention of urine, when the contents of the bladder are not evacuated, either spontaneously, or by means of the catheter, decomposition of the urea commences, and a small quantity of it is converted into sub-carbonate of ammonia. The urine, however, does not entirely lose its acid properties. It is in such cases that we occasionally observe the urine to deposit sub-carbonate of lime on ebullition. When the retention has been prolonged, is of long standing, and recurs frequently, there is generally some modification of the urine, together with incipient catarrh of the bladder. The following change then takes place.

The prolonged retention of acrid urine irritates the lining membrane of the bladder; a larger amount of mucus than usual is secreted, it becomes altered in quality, and mixed with a small quantity of pus. Two causes, therefore, contribute to the conversion of urea into sub-carbonate of ammonia: 1. Prolonged retention of urine; and, 2. The admixture of a certain amount of muco-pus.

Complete transformation of the urea at length takes place; the urine becomes alkaline, and is now still more irritating to the vesical mucous membrane, which, under these circumstances, secretes a larger amount of purulent matter than heretofore. We have here, then, double action and reciprocal influence: 1. Of the urine upon the mucous lining of the bladder, causing inflammation; 2. Of the product of the inflamed membrane upon the urine, modifying still further the character of this fluid.

The alkalinity of the urine, and the presence of a certain quantity of pus and mucus, are, therefore, the result of prolonged retention of urine.

9. *Of the urine in calculus and gravel.*—This is a subject upon which physico-chemists have exercised their utmost sagacity.

By what agency, we may here ask, do certain chemical constituents of the urine coalesce, so as to give rise to gravel? To this question we give for answer, that authorities are not all of the same opinion respecting the formation of these substances, nor do the facts observed, serve to throw much light upon the subject.

The following theory appears, to us, the most probable.

Two great classes of causes may contribute to produce that aggregation of the chemical elements of the urine which constitutes gravel.

1. Their proportion;
2. A special molecular condition, due, in all probability, to certain modifications of their physical properties.

The coincidence of these two causes is often indispensable; at other times, one or the other may suffice; but in many cases, one alone, the first especially, has no effect.

1. Proportion of the chemical constituents:

It is generally admitted, that an increased amount, whether absolute or relative, of the constituents of the urine, may give rise to gravel.

This is true in certain cases, but in the majority it is not so.

We may examine, for instance, individuals labouring under protracted disease, whose urine almost invariably shews an excess of uric acid, which is precipitated in the form of a copious pulverulent deposit.

Is gravel, however, observed in such cases? We think not.

It may be met with occasionally, but under other circumstances: thus, in persons who habitually take a large amount of nutritious, highly nitrogenized food, and but little exercise, we frequently, if not always, find a deposit of amorphous uric acid in the urine. After the lapse of a certain time, it may happen, that the urine of such persons will contain gravel; but such is not the necessary consequence of their habitual condition.

In other individuals, whose urine is always alkaline, phosphatic deposits are far from being common.

This arises from the fact, that the second necessary condition, previously mentioned, exercises a far more powerful influence. This condition is, as we have seen, a special molecular arrangement of the chemical elements which exist in the urine.

How is it, we may ask, that in persons whose urine so frequently and for so long a time, contains deposits of uric acid and its compounds, gravel is so rarely met with? It is from being almost invariably combined with a small proportion of animal matter, which renders it amorphous, and destroys its property of aggregation. Collect such deposits, dry them carefully, and you will never obtain aught but a solid substance without cohesion, and which the smallest effort will reduce to powder. The uric acid, therefore, must be in some particular condition, which is, in fact, the crystalline. Although rarely met with in the urine in this form, it is so occasionally, and we are convinced, as the result of actual observation, that the presence of crystallized or crystallizable uric acid in the urine, is one cause of gravel. It will be observed that we speak here of uric acid, without using the word *excess*. Without doubt, when in undue proportion, the tendency to the formation of gravel will be still greater; but it may nevertheless occur in urine containing no excess of this principle. We have observed this on two remarkable occasions: the first was that of a man admitted into the Hôpital de la Charité, with violent nephritic colic. He voided, along with the urine, several specimens of red gravel. The urine was perfectly healthy, nor was there the slightest excess of uric acid.

The same fact was noticed in a girl, eighteen years of age, admitted into the Hôtel Dieu, for nephralgia.

If, in some cases, we assert the crystalline condition of the uric acid, and its freedom from admixture with animal matter, to be the cause of the formation of gravel, we cannot do so in all, inasmuch as the uric acid and urates, of which it is composed, are not unfrequently in an amorphous state: in such cases, we presume them to possess some unknown property, in virtue of which they are enabled to coalesce; of this peculiar property, however, we know nothing.

The formation of ammoniaco-magnesian phosphatic gravel may be more readily conceived. The urine in which it forms must be alkaline, and the salt is always precipitated in a crystalline form. It is not surprising, therefore, that when these phosphates become very abundant, the crystals should coalesce and give rise to the formation of still larger ones, constituting gravel.

Gravel composed of phosphate of lime is very rare: this is doubtless owing to its existing in the urine as an amorphous substance.

That of cystine is equally rare. It occurs under circumstances of which we are entirely ignorant. Oxalate of lime calculi and gravel may be easily conceived to exist in the urine of those who make use of articles of food containing oxalic acid or oxalates, such as sorrel, etc., etc. It is sufficient for a healthy individual to have partaken of such a vegetable at dinner, to discover, on the morrow, crystals of oxalate of lime in his urine.

If, then, we suppose a healthy person to make habitual use of food in which a large proportion of oxalates exists, it follows that his urine will, almost of necessity, contain a certain number of crystals of oxalate of lime, which are all but insoluble. The aggregation of these small crystals into one or more of larger size, may be readily understood, since a similar result can easily be produced artificially in a chemical laboratory.

This, however, is not always the case; for in the absence of such a cause, and without the use of food containing oxalic acid or oxalates, this variety of gravel may yet occur. Of the mechanism of its production we know nothing, and we might ask with Vogel, whether the oxalic acid may not be regarded as a substance derived from the uric acid, but containing less oxygen than this latter, and liable to be formed under certain circumstances, hitherto undetermined. It is not our intention here, to enter fully into the subject of gravel and calculus, and we shall terminate this section, by describing the chief characteristics of the different species of gravel.

1. *Uric acid gravel:*

Its colour is reddish, bordering occasionally upon yellow. It is readily soluble in alkalies, and more especially in solutions of potash. Nitric acid likewise dissolves it with effervescence; and if the product be evaporated to dryness, it assumes a fine red colour, attributed by Prout and others to hippuric acid. When exposed to the flame of a spirit lamp, this variety of gravel is entirely dissipated.

2. Gravel composed of ammoniaco-magnesian phosphates, crystallizes in four-sided prisms, terminating in four-sided pyramids or needles. They have a pungent taste and alkaline reaction. When thrown on heated charcoal, they disengage an ammoniacal smell; potash and soda likewise liberate the ammonia.

3. Oxalate of lime gravel is of a dark brown or blackish colour. By means of the blow-pipe, we can destroy the oxalic acid and obtain the lime, which may be recognized by the ordinary tests.

4. Phosphate of lime, rarely found as gravel in the urine, may be recognized by its ordinary characteristics.

5. Cystine, or cystic oxide, has been described when treating of the chemical properties of the urine.

10. *Urinary Calculi.*—All that we have stated respecting gravel is equally applicable to calculi in general. We have no

intention, therefore, of tracing their history. Numerous trustworthy works have been published on this subject, to which we may refer the reader, contenting ourselves with a very few words relative to the formation of these bodies.

1. In some cases, the cause which determines the formation of a calculus, is the presence of a foreign body in the urine; the deposition and crystallization of the different salts takes place around it.

2. At other times, a portion of gravel acts in a similar manner, and gradually increases in size, by the addition of new crystalline or amorphous layers.

3. The condition of the urine, in cases of calculus, may resemble that met with in the different species of gravel, the formation of which is due, rather to the peculiar state of those chemical constituents of which calculi are composed, than to their absolute or relative excess in the urine itself.

4. When a calculus actually exists in the bladder, the urine may either be healthy, or present similar qualities to those met with in vesical catarrh; in fact, this complication, to a greater or less degree, is by no means an uncommon accompaniment of stone in the bladder. M. Becquerel found this to be the case in several specimens of urine taken from patients affected with calculous disease, in the wards of the Charité, during the year 1839; but, we repeat, these cases are not sufficiently numerous to admit of our generalizing the proposition in question; we have merely endeavoured to propound certain considerations respecting the condition of the urine in calculous diseases, without attempting to trace the entire history of these affections.

11. *Organic diseases of the kidneys, ureters, bladder, and prostate.*—Whenever one or other of these organs is affected with cancerous or tubercular degeneration, and that the part so affected, whether softened or ulcerated, is brought into communication with the interior of the urinary passages, through the vesical mucous membrane, itself diseased, two new substances, viz., pus and blood, may pass into the urine. It is needless to revert to the changes which they produce there.

The following is a *resumé* of the researches of M. Rayer, relative to the condition of the urine in tubercular and cancerous disease of the kidney.

When tubercles exist in the kidney, the urine undergoes no change until the deposit begins to soften; it then becomes more or less turbid, and contains particles of organic matter, which are deposited along with the salts. Should the tubercular disease of the kidney coincide with a similar affection of the lining membrane of the bladder, we may sometimes meet with portions of mucous membrane infiltrated with tubercular matter.

In cancer of the kidney, we generally find blood in the urine, and sometimes in quantity sufficient to coagulate. The supernatant urine is turbid, of a dark dirty colour, and albuminous.

We shall not here allude to the parasites which are occasionally met with in the urine, but would refer the reader to the third volume of M. Rayer's treatise.

12. *Cysts of the Kidney.*—A woman, admitted into the Hôtel Dieu, died of acute peritonitis. At the autopsy, in addition to the ordinary appearances of inflammation, we found the kidneys transformed into a multitude of cells or cysts, some of which were isolated, but all were filled with a slightly albuminous serum, resembling urine. It was not, however, analysed. Both kidneys were equally diseased; they were nearly doubled in size; amid the numerous cysts, lined with a smooth, polished, delicate membrane, were found, here and there, fragments of cortical or tubular substance, irregularly scattered about; the pelvis of the kidney, though altered in shape, could still be distinguished. The urine was daily examined, except during the last stage of the disease, when it was passed involuntarily; it presented all the characteristics of anæmia. The patient was exceedingly debilitated, and the feverish symptoms were but slight.

These numerous cysts, therefore, had in no respect modified the urine, this fluid being merely under the influence of the constitutional state of the patient.

ARTICLE V.

OF THE SEMINAL SECRETION, OR SPERMATIC FLUID.

The seminal secretion is a complex fluid, derived from the united secretions of the testicles, vesiculi seminales, and prostate gland. It is thick, whitish, viscid, somewhat gelatinous, semi-transparent, and endowed, moreover, with a peculiar odour.

When examined under the microscope, we perceive an immense number of spermatozoa, moving about freely. We likewise find large and numerous bright molecular granules (Wagner), varying from the $\frac{1}{300}$ to the $\frac{1}{400}$ of a line in diameter. A considerable number of epithelial cells are also met with.

The seminal fluid, at the moment of emission, is somewhat turbid, and mingled with the mucous secretion of the prostate gland, from which it cannot be separated. Its consistence varies, in proportion to the length of time that it has remained in the vesiculi seminales and testicles. It is to Vauquelin, Jourdan, and John, that we are indebted for the most accurate information relative to the composition and properties of the seminal fluid.

This fluid, when left to itself for a certain length of time, becomes more transparent and limpid, and may be almost entirely dissolved in water. If, on the contrary, it is thrown into water when first ejected, it immediately sinks, and coagulates in filaments, as though alcohol had been added.

The precipitated mass is soluble in acetic acid, and this solution may, in turn, be precipitated by ferro-cyanide of potassium.

The coagulum formed by the spermatic fluid, when thrown into water and left there, is at last completely dissolved, leaving only a few whitish flakes.

The seminal secretion, when left to itself, presents on the surface a number of quadrilateral prisms, arranged in the form of stars and terminating in four-sided pyramids. These have been regarded by Berzelius and Vauquelin as ammoniaco-magnesian phosphates. When nearly dry, the spermatic fluid becomes covered with a pellicle, in the midst of which may be observed white points, composed of crystals, analogous to those of which we have just spoken, with the addition of crystals of phosphate of lime.

When the secretion has lost all its water by evaporation, there remains a yellow, elastic, semi-transparent mass, of about one-tenth the weight of the original fluid.

According to Vauquelin, the recent seminal fluid is soluble in all acids; while alkalies cannot precipitate it from the solution thus formed. It is equally soluble in alkalies, after which it cannot be precipitated by acids.

The addition of alcohol to fresh semen, coagulates it in long whitish filaments, which cannot be redissolved. When dried in this state, it affords an opaque, white, elastic mass; this, on the addition of water, swells like mucus, but does not dissolve. Berzelius, who carefully studied the semen, concludes, as the result of his researches, that this fluid contains a peculiar substance, to which he has given the name of *spermatine.*

Spermatine is, according to Berzelius, a fluid substance, existing in a suspended condition in the semen, as though it were mucus. It differs from mucus, however, in that, when removed from the body, it possesses the property of being soluble in the same fluid in which it had merely been as it were suspended; and when once thus dissolved, it produces a clear fluid, which heat does not coagulate. It is this property which distinguishes spermatine from all other animal substances.

Spermatine, that has been coagulated by alcohol, may be dissolved in concentrated sulphuric acid, and the solution presents a yellow colour. That portion which has been dissolved, forms a white precipitate in water, while those which had been simply expanded by the acid, without being dissolved, abandon the acid and retract upon the addition of water. The precipitate thus formed, cannot be redissolved by water, even when in large quantity and heated.

On the addition of nitric acid, the spermatine becomes yellow, but is not dissolved. It is precipitated by water.

Acetic acid renders spermatine gelatinous and transparent; it may be dissolved in this acid by boiling, and the solution becomes turbid. The same effect is produced by ferro-cyanide of potassium. Carbonate of potash and bichloride of mercury produce no appreciable change. An infusion of galls produces a precipitate.

The following is the composition of the spermatic fluid, according to Vauquelin.

Extractive matter (spermatine)	6
Phosphate of lime	3
Soda	1
Water	90

According to John, the spermatic fluid is composed of a glairy matter, together with a small quantity of albumen; a substance soluble in æther, soda, phosphate of lime, chloride of sodium, and an odoriferous volatile principle.

From all this it is evident, that we possess, as yet, no very accurate quantitative analysis of the spermatic fluid.

Of the modifications of the spermatic fluid.—Various attempts have been made to investigate the modifications of which this fluid is susceptible; much, however, remains yet to be done.

Consistence.—The semen, at the moment of emission, is often but slightly viscid, and almost entirely liquid. Such a condition may occur under three different circumstances:

1. Spermatozoa still exist;

2. Spermatozoa are present in the secretion, but they are less lively, and die sooner than in the natural condition of the spermatic fluid;

3. These animalcules have entirely disappeared, and molecular granules can alone be detected.

These three conditions must be examined separately.

First Condition.—*The semen is more liquid than usual, but contains as lively and, we might say, as healthy animalcules, as though it were of normal consistence.*—In the first place, then, this liquidity of the semen may not take place previous to ejaculation, but only after the lapse of several minutes, or more. When, under such circumstances, we still find spermatozoa, we may regard the case as a rare one; the semen may indeed retain its fecundating properties, but these are much feebler than when the secretion in question is viscid and consistent.

SECOND CONDITION.—*The semen is more liquid at the moment of emission, or after the lapse of a few minutes; the spermatozoa are more sluggish than usual, and their movements rapidly cease, for the most part, during the time that the liquefaction of the seminal fluid is taking place.*—This is a much more frequent occurrence than the former. The fecundating property of the semen has less chance of being retained, and, in the majority of cases, it is completely lost.

THIRD CONDITION.—*The semen is liquid at the moment of emission, or after the lapse of a few minutes; it contains no spermatozoa, and the microscope reveals only the presence of molecular granules.*—This variety of the seminal fluid possesses no fecundating power. There are some authorities, however, who, refusing to admit the presence of spermatozoa as being absolutely necessary to the fecundating property of the semen, hold a contrary opinion. The truth is, that viscid and very consistent semen may be met with, containing few or no spermatic animalcules, or in which they die rapidly.

This is all we know of the changes occurring in the spermatic fluid. Our information, albeit limited, is not without interest, in relation to the diagnosis of certain cases of sterility.

As regards therapeutic deductions, we know but little of the means likely to restore the normal consistence of the seminal fluid, or to cause the reappearance of the spermatozoa. It is only by analogy, and upon general principles, that we recommend corroborants of every description, iron, quinine, sulphur baths, sea bathing, hydrotherapia, a nitrogenized diet, continence, moderate exercise, etc., etc. We know of no specific, worthy of confidence in such cases.

ARTICLE VI.

OF THE MILK.

It is only since the commencement of the nineteenth century, that precise notions have been acquired, respecting the chemical composition of milk.

The more ancient authorities merely described the mammary secretion, in accordance with its apparent physical properties. Thus, they investigated its colour, taste, odour, viscidity, and quantity. Occasionally they tested it by means of vinegar and heat. At the beginning of the seventeenth century, however, the microscope was first employed in the examination of the tissues and organic fluids: Borellus (1656) and Kircher (1658) applied the instrument to a study of the secretion in question; but it is to Leeuwenhoeck that we are indebted for the discovery of the milk globules (1722). To this experimenter succeeded Bonnain, Della Torre (1763), Hewson (1773), Gruithuisen (1809).

Among those who, since the commencement of the present century, have turned their attention to the subject of the milk and its composition, we may mention the following: Treviranus, Hodgkin, Lister, and Weber (1830), Wagner (1837), Burdach, Raspail, Donné, Dujardin, Turpin (1837), Mandl (1839), Gerber (1840), Vogel (1841), Simon (1838), Guterbock, Müller, Henle, Schultze, Kraüse, Harting, Nasse, Fuchs, d'Outrepont, Quevenne (1841), Devergie (1841), Romanet (1842).

The most remarkable researches have been those made by Parmentier and Deyeux (1800), Quevenne, Lhéritier, Boussingault, Simon, and Lehmann.

In accordance with the indications pointed out by M. Moigno, M. Poggiali has applied optical science to the investigation of the sugar of milk.

We might quote here, almost every treatise on obstetrics and on the diseases of women and children, as containing more or less interesting researches, respecting the composition and properties of human milk.

Lastly, we may, perhaps, be permitted to quote the work published by ourselves, in conjunction with M. Vernois, and from which the following chapter is extracted, or rather compiled.

SECT. I.—Method of Analysis.

The majority of authors who have analyzed the product of the mammary secretion, and made known the results thereof, appear to have omitted the details of the process necessary for the complete analysis of this liquid.

The following is the method adopted by MM. Vernois and Becquerel.*

About two ounces of milk are to be procured and divided into two equal portions. Of these, one is to be dried in a warm stove, at a temperature not exceeding from 60 to 80 degrees, centigrade measurement; this temperature is to be maintained without interruption, until desiccation be complete. We ascertain that this is the case, on finding that the solid residue no longer loses weight. It may even be left for some hours longer. When once thoroughly dried, the residuum is weighed, and the difference between the weight thus afforded and that of the milk when first placed in the stove, will give: *a.* The proportion of water; and, *b.* The amount of solid matters contained in an ounce of milk. The whole to be referred to 1000.

The solid residuum is now to be treated with æther. This is repeated several times, until the æther which passes through the filter, no longer appears to contain fatty matter. This part of the process gives us the weight of the butter in two different ways, each of which acts as a corrective to the other. Thus, if the residue be again dried, the decrease of weight which is found to have taken place, gives the amount of fatty matters. On the other hand, if we evaporate the filtered æther, we obtain the weight of the butyraceous matters. What remains, after the butter has been removed by the æther, contains the casein, sugar, extractive matters, soluble and insoluble salts. It is to be incinerated in a platinum capsule, and the burnt residuum will then give the proportion of salts contained in an ounce of milk. The whole to be again referred to 1000.

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* *Annales d'Hygiène*, p. 267.

We may here give an example of the above process in round numbers. Thus, an ounce of milk when dried gave one drachm of solid matters, and about seven of water. The drachm of solid matters, when treated with æther, gave in turn 15 grains of fatty matter (butter), and 45 grains of solid matter as residue, which last, when incinerated, afforded about 1½ grains of salts.

As for the remaining 43½ grains, they represent three principles: 1. The casein; 2. The sugar; and, 3. The extractive matters. The whole is to be referred, as before, to 1000. All that now remains to be done, is to obtain these substances in a separate form, and for this purpose we employ the second portion of milk, which was set aside at the commencement of the process. This portion is now to be coagulated, by boiling it with a drop or two of rennet, and a few drops of acetic acid. It is then to be filtered, the clear residue constituting the serum of the milk. This serum contains: 1. The sugar of milk; 2. The extractive matters; and, 3. The soluble salts.

To ascertain the proportion of sugar, the serum is submitted to the action of the polarimeter; and by reference to a table previously prepared, the deviation of the polarized ray will give the exact quantity of sugar contained in 1000 parts of milk serum.

By means of these two series of operations, we have obtained in succession, the weight: 1. Of the water; 2. Of the solid matters; 3. Of the butter; 4. Of the sugar of milk; and, lastly, of the salts. These results if referred to 1000 (according to our assumed numbers) give:

Water	886.67
Solid matters	133.33

These latter may be thus sub-divided:

Butter	33.32
Sugar of milk	35.00
Salts	3.00
Total	71.32

This sum total of 71.32 being subtracted from 133.33, which represents the proportion of solid matters, there remains 62.01, which stands for the weight of the casein in union with the extractive matters. These latter may be represented by 6 or 8; nor have we thought it necessary to isolate them, inasmuch as from their almost unascertained nature, they would serve merely to complicate the analysis. In this manner, we may ascertain the weight of the casein, without falling into the errors of those who have endeavoured to obtain the complete isolation of this principle.

We have, however, occasionally isolated the extractive matters in the following manner:

The residuum of coagulated milk is successively treated with water, alcohol, and ether; and, when each of these has been exhausted, the dried residuum is pure casein. We thus obtain the weight of the extractive matters; but, as we have already stated, there is no necessity for undertaking this long and complicated process.

To sum up, then, it is evident that by adopting the above method of procedure, we obtain, in the most accurate manner, the weight: 1. Of the water; 2. Of the solid matters; 3. Of the butter; 4. Of the sugar; 5. Of the casein in union with extractive matters; and 6. Of the salts by incineration.

SECT. II.—Analysis of the Milk of Healthy Nurses.

According to MM. Vernois and Becquerel, the composition of milk in the human female is as follows:

	Mean.	Maximum.	Minimum.
Specific gravity . . .	1032.67	1046.48	1025.61
Water (per 1000 parts) . .	889.08	999.98	832.30
Solid matters (ditto) . .	110.92	147.70	83.33
Sugar	43.64	59.55	25.22
Casein and extractive matters	39.24	70.92	19.32
Butter	26.66	56.42	6.66
Salts, by incineration . .	1.38	3.38	0.55

The above table is the result of eighty-nine analyses.

The following one shews the comparative results obtained by those who have made human milk the subject of experiment. In this table, these results are all referred to 1000 grammes.

	Meggenhofen, according to Burdach. — Mean of 2 experiments.	Meggenhofen, according to Lhéritier.	Payen. — Mean of 2 experiments.	Payen, according to Billard. — Mean of 3 experiments.	Payen, according to Müller. — Mean of 3 experiments.	Payen, according to Lhéritier. — Mean of 3 experiments.	Henri and Chevallier. — According to Lhéritier.	Lhéritier. — Mean of 2 experiments.	Quevenne.	Simon. — Mean of 5 experiments.	Schérer and Clemm, according to Simon. — Mean of 3 experiments.	Hellen. — Mean of 2 experiments.	Donné.	Regnault.	Lehmann.	Vernois and Becquerel. — Mean of 89 experiments.
Specific grav.	..	..	..	..	..	..	..	1018 to 1036	1032.030	1032.00	1018 to 1045	..	1032.00	..	1030 to 1034	1032.67
Water	836.25	879.00	858.00	858.00	857.60	868.30	879.80	869.20	892.50	890.20	890 15	910.50	879.00	880.00	897 to 890	889.08
Solid matters	163.75	121.00	142.00	142.00	142.30	131.70	120.20	130.80	107.50	109.80	109.85	89.50	121.00	111.00	110 to 130	110.92
Sugar	10.85 and soluble salts.	12.00 and soluble salts.	88.05 and soluble salts.	87.97 and soluble salts.	88.30 and soluble salts.	78.00 and soluble salts.	65.00 and soluble salts.	68.70 and soluble salts.	73.10 and soluble salts.	45.20	38.54	37.50	12.00	49.00	40 to 60	43.61
Casein	21.75 insoluble salts.	19.30 insoluble salts.	2.15 insoluble salts.	2.23 insoluble salts	2.20 insoluble salts.	1.90 insoluble salts.	15.20 insoluble salts.	10 60 insoluble salts.	Solid casein 4.0 Fluid casein 6.2 } 10.2	33.00*	32.50	29.00	19.30	39.00	35.00	39.24 and extractive matters.
Butter	126.20	89.70	51.80	51.80	51.80	51.80	35.50	47.30	21.20	30.00†	37 24‡	23.00	89.70	26.00	very var.	26.66§
Salts	1.95	..	..	..	..	..	4.50	4.20	..	1.60	1.57	..	..	..	1.60 to 2.50	1.38 by incineration. ‖

* According to Lehmann ....casein.. 35.00
† " " ......butter.. 25.30 to 38.80
‡ " " ......butter.. 42.97

MM. Chevallier and Henri give .... 31.30 of butter in 1000 grammes.
Hallden.......................... 31.00 good milk } for the casein in
Id. .... 27.00 inferior milk } 1000 grammes.

§ MM. Pfaff and Schwartz give the proportion of salts in the milk of the human female as 4.007 in 1000. Thus ....

Phosphate of lime	2.500	4.007
Magnesia	0.500	
Iron	0.007	
Soda	0.400	
Chlorate of potash	0.300	
Lactate of soda	0.300	

‖ Of the salts contained in human milk by MM. Vernois and Becquerel:

A portion insoluble in water but soluble in acids......	0.775	Carbonate of lime	0.069
		Phosphate of lime	0.706
		And probably a small proportion of other salts.	
A portion soluble in water..	0.225	Chloride of sodium............	0.098
		Sulphate of soda..............	0.074
		Other salts	0.053

Total...... 1.000

The small proportion of the salts forbids a more precise analysis.

NOTE.—The milk of the human female likewise contains a small quantity of albumen, the weight of which it is very difficult to ascertain. We may state, however, that the small quantity of albumen present, cannot have any effect upon the sugar, inasmuch as human milk does not coagulate completely until heated to ebullition.

A variety of circumstances may influence the composition of milk.

Of the influence of age, as regards the nurse.—This is a point of great importance, as bearing upon the choice of a nurse. Much diversity of opinion, however, here exists. Mauriceau recommends us to choose a nurse of from 25 to 35 years of age; Van Swieten, from 20 to 30; Chailly, from 20 to 30; Donné, from 18 to 34; Bouchut, from 20 to 35; and Michael Levy, up to 35 years of age.

As the result of numerous researches, published in the *Annals of Hygiène*, and based on a series of tables, the following conclusions have been arrived at, with reference to nurses of from 15 to 40 years of age.

The age of the nurse produces no sensible alteration of the specific gravity of the water, or of the solid matters of the milk. It is only at the extremities of the scale that we are able to detect an appreciable difference. The physiological standard is to be found between the ages of 20 and 30. Thus:

	From 15 to 20 years of age.	From 20 to 25 years.	From 25 to 30 years.	From 30 to 35 years.	From 35 to 40 years.	Normal condition.
Specific gravity .	1032.24	1033.08	1032.20	1032.42	1032.74	1032.67
Weight of water .	869.85	886.91	892.96	888.06	894.94	889.08
„ of solid matters	130.15	113.09	107.04	111.94	105.06	110.92
„ of sugar . .	35.23	44.72	45.77	39.53	39.60	34.61
„ of casein and extractive matters	55.74	38.73	36.53	42.33	42.07	39.24
„ of butter . .	37.38	28.21	23.48	28.64	22.33	26.66
„ of incinerated salts	1.80	1.43	1.26	1.44	1.06	1.38

Of the influence of age, on the part of the milk.—Upon this point authorities are not less at variance than upon the preceding one.

Mauriceau recommends milk of from one to two months, and never more than from three to four months old.

According to Levret, the quality and quantity of the milk are of more importance than its age.

Donné considers the best milk to be that, secreted at about the sixth month, or from that to the eighth month; Bouchu entertains a very similar opinion.

As the result of our researches, published in the *Annals o Hygiène* (p. 276), we are enabled thus to state the influence o age upon the composition of the milk.

From the first to the fifteenth day, there exists a certai amount of colostrum in the milk, which gives rise to the following modifications:

Low specific gravity;
Decrease of the water;
Increase of the solid matters;
Trifling, but almost invariable decrease of the sugar;
Marked increase of the casein;
„ „ of the butter;
Increase of the salts;

The analysis of the milk, from the fifteenth day to the twenty-fourth month, as made by MM. Vernois and Becquerel, will b found in the subjoined table.

	First month.	From 1 to 2 months.	From 2 to 3 months.	From 3 to 4 months.	From 4 to 5 months.	From 5 to 6 months.	From 6 to 7 months.	From 7 to 8 months.	From 8 to 9 months.	From 9 to 10 months.	From 10 to 11 months.	From 11 to 12 months.	From 12 to 18 months.	From 18 to 24 months.
Specific gravity	1031.69	1033.11	1032.70	1032.00	1032.10	1034.35	1034.97	1031.37	1032.88	1031.44	1031.61	1030.68	1032.05	1030.81
Weight of water	872.84	872.99	886.16	889.67	888.25	901.51	891.35	889.49	891.65	889.28	900.63	889.04	891.34	876.55
„ of solid matters .	127.16	127.01	113.84	110.33	111.75	98.49	108.65	110.51	108.35	110.72	99.37	110.96	108.66	123.45
„ of sugar	40.40	43.13	43.37	44.47	44.66	42.00	44.18	41.52	45.31	45.84	47.62	43.01	43.92	41.33
„ of casein and extractive matters	45.38	48.26	37.92	36.06	38.28	38.63	38.86	45.02	38.79	38.57	31.06	41.06	36.98	37.32
„ butter	39.55	34.05	31.22	27.70	27.31	16.57	24.35	22.79	23.06	25.03	19.47	24.61	26.44	43.47
„ of incinerated salts	1.83	1.57	1.33	1.41	1.50	1.29	1.26	1.18	1.19	1.28	1.22	1.38	1.32	1.33

The following general conclusions may be deduced from the preceding table.

Specific gravity.—This is liable to variations.

Water.—Its proportion is much increased from the fifth to the sixth month, as also from the eleventh to the twelfth. It is diminished from the first to the second month, and from the eighteenth to the twenty-fourth month.

Solid matters.—They undergo a marked increase from the first to the third month.

Sugar.—Its proportion decreases during the first month, but increases from the eighth to the tenth month.

Casein.—It increases during the first two months, and decreases from the tenth to the twenty-fourth month.

Butter.—It undergoes a considerable increase up to the fifth month, and a corresponding decrease from the fifth to the sixth, and from the tenth to the eleventh month.

Salts.—They likewise undergo a slight but progressive increase from the first to the fifth month, after which, they gradually decrease in quantity.

Of the influence of constitution, on the part of the nurse.—The following table shews the composition of the milk in nurses of a robust or enfeebled constitution, as contrasted with those in average health.

	Robust constitution.	Feeble constitution.	Average constitution.
Specific gravity . . .	1032.97	1031.90	1032.67
Weight of water . . .	911.19	887.59	889.08
„ of solid matters .	88.81	112.41	110.92
„ of sugar . . .	32.55	42.88	43.64
„ of casein and extractive matters . .	28.98	39.21	39.24
„ of butter . . .	25.96	28.78	26.66
„ of incinerated salts .	1.32	1.54	1.38

The above table shews:

a. A lower specific gravity in those of a feeble habit of body.

b. An increase of the water in the opposite condition, and, as a necessary consequence, an inverse proportion of the solid matters.

In nurses of robust constitution, the sugar and casein appear to be in less than average proportions; this, however, is not the case in nurses of a weak habit of body.

In these last, the proportion of butter is slightly increased; in the former, the reverse occurs.

The salts afford similar results.

Of the influence of repeated childbearing upon the milk.—The following table shews the difference in the composition of the milk of primiparæ on the one hand, and of multiparæ on the other.

	In primiparæ.	In multiparæ.	Normal condition.
Specific gravity . . .	1031.84	1032.30	1032.67
Weight of water . . .	889.35	885.53	889.08
„ of solid matters .	110.65	114.47	110.92
„ of sugar . . .	44.14	46.82	43.64
„ of casein and extractives . . .	39.46	39.27	39.24
„ of butter . . .	25.66	27.01	26.66
„ of incinerated salts .	1.39	1.37	1.38

It is evident from the above table, that in multiparæ the butter and sugar undergo a trifling increase, whilst the casein and salts retain their normal proportions.

Influence of Gestation.—Almost all authors who have made the milk of the human female an object of investigation, agree in forbidding the use of milk derived from pregnant women. Few mothers allow their children to be suckled by nurses so circumstanced, and hence, it is difficult to institute a chemical examination of the milk in the pregnant female. We know of no analysis of this fluid, previous to that made by MM. Vernois and Becquerel, upon the milk of the same individual, before and during gestation.

	At the third month.	Normal condition.
Specific gravity	1030.67	1032.67
Weight of water	860.97	889.08
„ of solid matters	139.01	110.92
„ of sugar	46.47	43.64
„ of casein and extractive matters	34.52	39.24
„ of butter	55.97	26.66
„ of incinerated salts . . .	2.05	1.38

It appears from this table, therefore, 1. That the specific gravity of the milk is diminished during pregnancy, owing to the increased proportion of butter ; and 2. That the proportion of water is likewise less than natural, whilst that of the solid matters and salts is above the average.

Should further observations be eventually made, it would be interesting to ascertain whether gestation,.especially towards its termination, invariably produces an increase in the proportion of solid matters, by diminishing that of the water. Should this prove to be the case, we might naturally ask, whether such milk would not be of more difficult digestion than that of a non-pregnant female, and whether some children so nursed, might not be seriously affected. It is easy, however, to conceive, that in numerous instances such milk might be taken with impunity.

Of the Influence of the Development of the Mammæ.—On this point, the majority of authors have expressed themselves in vague terms.

From certain analyses published in the *Annals of Hygiene*,* it would appear, that the development of the breasts exercises no marked influence upon the composition of the milk.

Of the Influence of Retention of Milk in the Breasts.—In the human female this produces no modification in the different constituents of the mammary secretion.

Of the Influence of Menstruation.—Much diversity of opinion exists among authors, relative to the influence of menstruation upon the milk of the human female. The majority, however, allow† that it undergoes certain changes during the catamenial flow. Hence, the popular prejudice which immediately produces the dismissal of a nurse, as soon as she is discovered to be menstruating. Hence, also, arises the difficulty of procuring a specimen of milk under such circumstances.

In the researches formerly alluded to, as published in the *Annales d'Hygiene*,‡ eighty-nine cases are quoted ; of these, there were seventy-nine in which the catamenia were absent, and ten in which it had reappeared; in three of these latter, the milk was examined during the flow itself.

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* Vernois et Becquerel, p. 297.

† *Annales d'Hygiene*, p. 302.

‡ *Annales d'Hygiene*, p. 304 and 305.

The following table illustrates the influence of menstruation upon the composition of the milk:

	Suspension of the catamenia.	Return or coexistence of ditto.	Actual presence of ditto.	Normal condition.
Specific gravity . .	1032.24	1031.94	1031.48	1032.67
Weight of water . .	889.51	886.44	881.42	889.08
„ of solid matters .	110.49	113.56	118.58	110.92
„ of sugar . .	43.88	41.68	40.49	43.64
„ of casein and extractives .	38.69	43.58	47.49	39.24
„ of butter . .	26.54	26.98	29.15	26.66
„ of incinerated salts	1.38	1.32	1.45	1.38

From the above table, we may draw the following conclusions:

The *specific gravity* of the milk, although almost natural during the suspension of the catamenia, falls progressively, as they become re-established.

The *proportion* of water decreases in a still more marked degree, but alike progressively.

The *proportion of solid matters* increases in an inverse ratio.

The *sugar* undergoes a progressive decrease.

The *casein*, a marked increase.

The *butter* increases likewise, but in a less degree.

Lastly, the *salts* increase somewhat, during the *actual presence* of the catamenia.

To sum up, then; the coexistence or return of the menses produces a diminution of the specific gravity, a decrease of the water and of the sugar, and an increase of the solid matters and casein; the butter and the salts remain unchanged.

Hence, it would appear, that the milk is but little altered in these cases, and we may therefore question the occurrence of those accidents, so frequently attributed to the return of the catamenia during the period of lactation.

In the different cases which furnished the specimens of milk from which the preceding analyses were deduced, the infants suckled by the nurses while menstruating, continued to enjoy good health, and lost none of their habitual sprightliness.

Of the Influence of the Colour of the Hair.—The greater number of authorities assert, that there is no relationship between the colour of the hair and the composition of the milk (Donné and Devergie). This opinion, however, is at variance with that of Lheritier.

It would appear from his researches published in the *Annals of Hygiene*, p. 311, that the milk of brown-haired women is of higher specific gravity, and contains more water and solid matters, with the exception of butter, than that of fair-haired women.

From this it would appear, that the milk of dark-haired women is to be preferred.

Influence of Alimentation.—The influence of alimentation upon the composition of the milk, has been noticed in the work previously quoted. Of eighty-nine women whose milk was made the subject of analysis, sixty-eight had been accustomed to good diet, and twenty-one to an indifferent diet. In the former, the figures representing the composition of the milk differed but little from the normal standard; there was a slight increase of density, as well as of the solid matters, and a trifling decrease of the sugar.

In the latter category, the *specific gravity* was found to have fallen, the proportion of *water* was greater, and that of the *solid matters* less than usual; the sugar was unchanged, the *casein* and *butter* were diminished, and the *salts* slightly increased. In this case, therefore, the influence of an indifferent diet is shown, in the decrease of two important elements of the milk, viz., the *butter* and the *casein*.

To sum up, then: insufficient nourishment causes the introduction of an undue quantity of water into the milk; by reason of which, its specific gravity falls, and the proportion of solid matters is diminished. The butter and casein being more especially affected.

Of the Influence of the Nurse's Health upon the Milk.—

When the child's health is good, the mother's milk is seldom found to differ much from the physiological standard.

On the contrary, when the nurse is in bad health, we find the following changes:

Decrease of the specific gravity (owing to the increase of the butter);

Diminished proportion of water;

Increase of the solid matters;

Normal condition of the sugar and casein;

Great increase of the butter;

Slight increase of the salts.

The above results are curious. We might ask, with the authors of the work alluded to, whether this great increase of the butter be not a pathological condition of the milk, and whether it may not be productive of derangement in infants so nourished. Thus, whenever we fail to meet with, either in the constitution of the nurse, in the appearance of her milk, or in the child's organs, a cause sufficient to explain the occurrence of gastro-intestinal disturbance in the latter, we may have recourse to a quantitative chemical analysis of the milk of the mother or nurse, and there, in all probability, will be found the cause of such disturbance, viz., an excess of butter or caseine.

Of the Influence of Quantity, on the part of the Milk.—It appears from an examination of the tables published in the *Annals of Hygiene*, that if we compare, with the healthy standard, those cases in which there is a very abundant supply of milk, we shall find that this liquid remains within its strict physiological limits.

When, on the contrary, there is but little milk, it contains, strange to say, more water and a smaller proportion of solid matters.

The advantage of an abundant supply of milk is, that it approaches nearest to the true physiological standard; while the disadvantages of a limited quantity of this fluid are to be explained, by reference to the diminished proportion of its solid matters, to the increase of the water and of the butter, and lastly, to the decrease of the sugar, casein and salts.

Hence it follows, that nurses having an abundant supply of milk, are necessarily to be preferred.

As regards the general composition of the milk in healthy nurses, we cannot do better than reproduce the conclusions deduced from the researches previously quoted, as published in the *Annales d'Hygiene.*[*]

In the normal condition, the following is the composition of 1000 parts of milk.

Water	889.08
Solid matters	110.92
Sugar	43.64
Cascin and extractive matters	39.24
Butter	26.66
Incinerated salts	1.38
Specific gravity	1032.67

The constituents of the milk are here ranged in their order of importance.

The age of the nurse produces no appreciable change in the weight of water, in that of the solid matters, or in the specific gravity. It is only at the extremities of the scale that there exists a difference. The casein, butter, and salts are found in the same proportions from fifteen to twenty, and from thirty to thirty-five years. At other periods they undergo a change, with the exception of the sugar.

There is found in the milk of nurses of from fifteen to twenty years of age, a much larger proportion of solid matters than in that of nurses of from thirty-five to forty years of age.

The period of life during which the milk approaches nearest to the normal physiological standard, is between the age of twenty and thirty.

From the first to the fifteenth day there is found an *invariable* decrease in the proportion of water (owing to the excess of butter), an increase (in inverse ratio) of the solid matters, and a decrease of the sugar, casein, butter, and salts; the specific gravity, moreover, is somewhat less.

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[*] Vernois et Becquerel, p. 319.

The colostral stage, so to speak, more especially affects the butter, the proportion of which is increased. The composition of the milk, as traced from the first to the twenty-fourth month, presents the following modifications.

1. As regards the *specific gravity*. This may vary by one or two units in either direction, but such variations are amenable to no fixed laws, nor are they progressive.

Of the water.—Marked increase in quantity, from the fifth to the sixth, and from the tenth to the eleventh month, and corresponding decrease from the first day to the second month.

Of the solid matters.—Marked increase from the first to the third month.

Of the sugar.—Marked increase from the eighth to the tenth month; decrease from the first day to the end of the first month.

Of the casein.—Increase from the first day to the second month ; decrease from the tenth to the twenty-fourth month.

Of the butter.—Increase from the first day to the second month ; decrease from the fifth to the sixth, and from the tenth to the eleventh month.

Of the salts.—Gradual, but trifling increase from the first to the fifth month ; progressive decrease at other periods.

In feeble constitutions, the composition of the milk varies but little. In robust constitutions, the weight of the solid matters decreases : the sugar and casein being more particularly affected.

Chemically speaking, the milk of primiparæ approaches nearer to the physiological standard than that of multiparæ.

The proportion of solid matters is increased towards the latter period of gestation. At its commencement, however, no change is observed in the milk.

The development of the breasts exercises no marked influence upon this fluid.

The influence of menstruation may be summed up thus :

The mean results afforded by analysis, in those cases where there is suspension of the catamenia, approach very closely to the physiological standard.

The return, or coexistence of the discharge, produces a decrease of the specific gravity of the water and of the sugar, but an increase of the casein and solid matters. The butter and salts remain unaltered.

The actual presence of the catamenia does not diminish the specific gravity of the milk : the weight of water and of sugar causes a considerable increase in that of the solid matters. The casein being more especially affected.

The milk of dark-haired women is superior in quality to that of fair-haired women, inasmuch as it approaches nearer to the physiological type.

The mean results afforded by an analysis of the milk of well-fed nurses, are almost identical with those afforded by milk whose composition may be regarded as typical.

Insufficient nourishment, on the other hand, causes the introduction of a larger amount of water than usual. The specific gravity of the milk and the proportion of solid matters fall therefore ; the casein and butter being more especially affected.

When the infant's health is satisfactory, we find, in the milk of the mother, a very close approximation to the physiological standard.

When, on the contrary, the infant is in bad health, we invariably find a decrease of the specific gravity, a diminished weight of water, and an increase of the solid matters, bearing considerably upon the butter, but not upon the sugar and casein.

An abundant supply of milk does not affect its specific gravity. The weight of water diminishes somewhat, and the sugar undergoes a slight increase, as does also the casein. The butter and the salts decrease, but not to a great extent.

When the supply of milk is scanty, the water is usually found increaseed in quantity. As regards the solid matters, the sugar and casein decrease, while the butter increases.

SECT. III.—Analysis of the Milk of Sick Nurses.

Upon this point science as yet possesses but little accurate information. The subject, however, is one of importance, inasmuch as there still prevails an almost universal opinion, that the moment a nursing female is taken ill, her infant should be removed.

The authors of the memoir formerly quoted, have endeavoured to elucidate this point, by analyzing the milk in forty-six such cases. In nineteen of these, the nurses were labouring under acute febrile disease, and in twenty-seven they were affected with some form of chronic disease.

Acute Disease.—Without pretending to draw any positive conclusions, the authors of the memoir in question drew up a table, comprising the general results obtained by an analysis of the milk in nurses suffering from acute diseases. We subjoin this table.

	Mean.	Maximum.	Minimum.	Normal condition.
Specific gravity . .	1031.20	1035.28	1025.57	1032.67
Weight of water . .	884.11	911.35	869.22	889.08
„ of solid matters .	115.09	130.78	75.66	110.92
„ of sugar . .	33.10	48.71	19.50	43.64
„ of casein and extractive matters	50.40	66.26	34.62	39.24
„ of butter . .	29.86	56.37	5.14	26.66
„ of incinerated salts	1.73	6.95	0.67	1.38

It is apparent, on examining the above table, that in acute febrile diseases generally, the milk undergoes certain modifications, which are as follows:

A trifling decrease of the specific gravity;
Marked decrease of the water;
Increase of the solid matters;
Evident decrease of the sugar;
Increase of the casein;
Increase of the butter;
Slight increase of the salts.

Thus, the milk, in acute diseases, undergoes, like most of the other important secretions, a marked diminution in point of quantity. The solid matters increase, and the water decreases.

We shall extract from the memoir previously alluded to, the table destined to shew the influence exercised by the different acute febrile affections, upon the composition of the milk.

	Acute enteritis. — 1 Case.	Acute pleurisy. — 1 Case.	Acute colitis. — 1 Case.	Great mental disturbance with fever. — 1 Case.	General indisposition, fever. — 1 Case.	Metro-vaginitis, acute fever. — 4 Cases.	Acute metro-peritonitis. — 9 Cases.	Typhoid fever. — 1 Case.	Normal condition.
Specific gravity	1038.68	1033.98	1025.57	1032.99	1032.44	1033.40	1030.30	1031.74	1032.67
Weight of water	883.22	888.95	869.60	908.93	880.32	884.70	885.09	924.34	889.08
„ of solid matters . . .	116.78	111.05	130.40	91.07	119.68	115.30	114.91	75.66	110.92
„ of sugar	31.21	32.94	32.02	34.92	32.14	40.00	30.07	31.46	43.64
„ of casein and extractive matters	50.30	42.86	42.86	50.00	47.70	56.71	48.33	32.91	39.24
„ of butter	31.53	54.12	54.18	5.14	38.89	17.12	35.03	9.09	26.66
„ of incinerated salts . .	1.74	1.40	1.40	1.01	6.95	1.47	1.48	2.20	1.38

The following table shews the cases in which the different constituents of the milk were at their maximum and minimum.

	Specific gravity.	Weight of water in	Solid matters in	Sugar in	Butter in	Casein in	Salts in
Minimum.	In acute colitis.	Colitis.	Typhoid fever.	Metro-peritonitis.	Mental derangement.	Typhoid fever.	Pleurisy.
Maximum.	In pleurisy.	Typhoid fever.	Colitis.	Metro-vaginitis.	Colitis.	Metro-vaginitis.	General derangement

Chronic Diseases.—The milk was analyzed in twenty-seven cases of chronic disease. The following table serves to shew the changes which the milk underwent in these cases.

	Mean.	Maximum.	Minimum.	Physiological standard.
Specific gravity . . .	1031.47	1037.52	1027.07	1037.67
Weight of water . .	885.50	923.58	832.96	889.08
" of solid matters .	114.50	167.04	89.51	110.92
" of sugar . .	43.37	57.98	30.38	43.64
" of casein and extractives . .	37.06	47.49	12.70	39.24
" of butter . .	32.57	73.05	6.90	26.66
" of incinerated salts	1.50	3.38	0.61	1.38

The following general conclusions may be drawn from this table.

In the first place, the specific gravity falls; this is especially due to an increase of the butter, which may rise as high as 73.05 instead of 26.66.

The proportion of water diminishes, but to somewhat less extent than in acute disease.

On the other hand, the weight of the solid matters increases, in the same proportion; this is a novel fact, and one which is entirely opposed to the opinion of physicians in general, who have hitherto been disposed to consider the milk of nurses labouring under chronic disease, as necessarily impoverished, or, in other words, as containing a larger proportion of water than in health.

This increase, however, of the solid matters, differs somewhat from that which takes place in acute diseases. In the latter, the sugar alone loses weight; in the former, it is the casein which falls below the physiological standard (12.70 being the minimum). The butter is that constituent of the milk, of which the increase is greatest; thus we have seen it rise as high as 73.05 instead of 26.66. The sugar remains unchanged in point of quantity; the salts increase slightly.

We may now proceed to examine the influence exerted upon the milk, by several chronic diseases in particular.

For this purpose, we have selected from the tables, published in the *Annals of Hygiene*, the following extracts.

	Chronic pleurisy. — 2 cases.	Chronic diarrhœa and enteritis. — 1 case.	Chronic metro-vaginitis, with emaciation. — 1 case.	Tubercular bronchitis and hæmoptysis. — 5 cases.	Tubercular phthisis, with diarrhœa. — „	Ditto ditto, without diarrhœa. — „	Mammary abscess, without fever. — 5 cases.
Specific gravity	1032.74	1032.28	1030.81	1031.41	1031.38	1031.84	1031.22
Weight of water	892.84	861.34	878.35	892.53	903.16	876.59	887.08
„ of solid matters.	107.16	138.86	121.65	107.47	96.84	123.41	112.92
„ of sugar .	45.26	50.25	42.25	42.93	43.45	42.14	41.72
„ of casein and extractives.	36.46	39.19	25.21	38.46	39.14	37.46	35.89
„ of butter .	24.25	48.53	51.98	24.39	12.76	41.82	34.23
„ of incinerated salts . .	1.19	0.89	2.21	1.69	1.49	1.99	10.8

The above table merely affords mean results, on examining which, we find that, in *chronic pleurisy*, the composition of the milk differs but little from that of health. The weight of water, and of the solid matters, undergo a trifling variation; the sugar alone increases, while the three remaining constituents decrease somewhat.

In *chronic enteritis*, we can draw no positive conclusion from a single case of the disease. It may be noticed, however, that the water falls to a very low figure, while the solid matters increase in a similar ratio, this increase bearing chiefly upon the butter and sugar. The casein remains unchanged, while the salts are diminished by one half.

In one case of *chronic metro-vaginitis with emaciation*, the water was greatly diminished in quantity; the proportion of butter was much greater, and that of the casein less than in health.

In *tubercular disease of the lungs*, the mean results offer nothing of special interest; nor was there found much difference between the composition of the milk in the five phthisical females, and that of nurses who were in perfect health.

On taking, however, into consideration, the absence or existence of diarrhœa, the question assumes more interest.

In cases of phthisis, attended with diarrhœa and emaciation, the proportion of solid matters undergoes a marked decrease.

The sugar, the casein, and the salts, are, comparatively speaking, but little altered, while, on the other hand, the proportion of butter is greatly diminished, its representative number falling to 12.76, while that of the solid matters, standing at 123 in cases free from diarrhœa, falls to 96 in cases where this complication is present.

If, then, upon considering merely the elementary composition of the milk, it were allowable to sanction the use of that derived from females labouring under tubercular disease of the lungs, we should require at once to establish a distinction between those in whom diarrhœa, great emaciation, and vomicæ were present, and those in whom these phenomena were either absent, or but little marked. We need scarcely add, that the milk of the former should be strictly proscribed.

In cases of mammary abscess, the composition of the milk differs but little from that of health. The casein and sugar undergo a slight diminution, which is compensated for by an increase of the butter. The salts decrease somewhat, but the proportion of water remains unchanged.

Syphilis.—The question relative to the composition of the milk in syphilis is one of the greatest importance, as throwing some light, in all probability, upon the subject of hereditary transmission, and perhaps shewing, whether the milk be really the vehicle through the medium of which, the elements of the virus are transmitted from the diseased nurse to the infant.

We subjoin the following table, extracted from the memoir published in the *Annals of Hygiene*, by MM. Vernois and Becquerel, page 90.

Syphilis (nine cases).

	Mean.	Maximum.	Minimum.	Normal condition.
Specific gravity . .	1034.05	1037.52	1027.75	1032.67
Weight of water . .	902.38	907.35	880.78	889.08
„ of solid matters .	97.62	119.22	92.65	110.92
„ of sugar . .	44.21	54.73	31.33	43.64
„ of casein and extractives . .	35.26	40.73	26.53	39.24
„ of butter . .	15.87	29.80	9.12	26.66
„ of incinerated salts	2.28	2.49	2.20	1.38

From this table we may draw the following conclusions.

In eight cases out of nine, there was a great increase of the specific gravity. This, however, cannot be attributed to a corresponding increase of the solid matters, inasmuch as these were very greatly reduced in quantity. It is most probably due, however, to the great decrease of the butter, and to the increase of the salts; for it is worthy of notice, that the butter and casein actually suffer a very considerable diminution. The sugar increases somewhat, and the weight of the salts is double that met with in health. The proportion of water is greatly increased, and that of the solid matters much diminished.

We may, therefore, thus sum up the composition of the milk in disease, as laid down by the authors of the memoir inserted in the *Annals of Hygiene.*

Practical Consequences deducible from an Analytical Examination of the Milk of Sick Nurses.

In acute febrile diseases, the composition of the milk, per 1000, was as follows:

Specific gravity	1031.20
Water	884.91
Solid matters	115.09
Sugar	33.10
Casein and extractive matters	50.40
Butter	29.86
Incinerated salts	1.73

Thus we see, that the proportion of solid matters is much increased; this increase bearing, more especially, upon the butter, casein, and salts. The sugar decreases in like proportion.

Enteritis, colitis, pleurisy, metro-vaginitis, and metro-peritonitis present a remarkable uniformity in their influence upon the milk.

This is not, however, the case in typhoid fever and in violent mental emotion, where *all* the solid parts of the milk diminish in quantity, except the casein, which retains its normal proportions. The sugar decreases; but the butter, which increases in other cases, here falls to its minimum.

In chronic disease, with but little or no fever, the following was found to be the composition of 1000 parts of milk.

Specific gravity	1031.47
Water	885.50
Solid matters	114.50
Sugar	43.37
Casein and extractive matters	37.06
Butter	32.57
Incinerated salts	1.50

Here, as in acute diseases, the proportion of water decreases, while that of the solid matters increases. The main difference being a diminution of the casein, which, in the former class of diseases, undergoes a considerable increase.

Ophthalmia, pleurisy, diarrhœa, low diet, bronchitis, metro-vaginitis, pulmonary tubercle (in general), and mammary abscess, all afford very similar results.

A distinction, however, must be made:

1. In the case of tubercular disease of the lungs, with diarrhœa and marasmus. In such cases, the proportion of solid matters is much diminished, the butter being more especially affected.

2. In the case of syphilis, in which the specific gravity is greatly increased, as are also the salts, while the butter undergoes a marked decrease in quantity. These conditions are peculiar to syphilis. Anti-syphilitic treatment, by means of mercurials, increases the proportion of butter in the milk.

After having thus determined the physiological composition of the milk, under different circumstances, together with the various modifications which it undergoes in acute and chronic disease, as revealed by analysis, we must cast a retrospective glance over the ground on which we have trodden, endeavouring to ascertain how far each constituent of the milk is affected, and whether absolutely or relatively.

SECT. IV.—Of the Physico-Chemical Properties of the Milk, separately considered.

A. SPECIFIC GRAVITY.

An analysis of the milk affords the following results:*

Whenever the sugar or the salts increase or decrease, the specific gravity remains unchanged. When the water and butter increase, the specific gravity falls; and when these constituents decrease, it rises.

The specific gravity rises with an increase of the casein; a decrease of this latter principle, however, has but little influence.

Lastly, when the sum-total of the solid matters is increased, as contrasted with the opposite condition, the specific gravity rises.

B. WEIGHT OF WATER AND SOLID MATTERS.

Whenever the four chief constituents of the milk are in excess, the water diminishes, and *vice versa*.†

This diminution in the proportion of water, is effected by an increase of the solid matters, in the following order:—1. Of the butter; 2. Of the salts; 3. Of the casein; and lastly, of the sugar: reciprocally, an increase of the water entails a decrease: 1. Of the butter; 2. Of the sugar; 3. Of the salts; and lastly, of the casein.

C. SUGAR.‡

The gradual development of the sugar, after the birth of the child, and considered with reference to the age of the milk, is not strictly progressive. From being, at first, in excess, it appears gradually to decrease; whilst the casein, on the other hand, undergoes a slow progressive increase.

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* *Annals of Hygiene*, p. 98. † *Ibid.*, p. 100. ‡ *Ibid.*, p. 102.

The modifications to which the sugar is liable, in cases of disease, have been already treated of. We shall, therefore, insist merely upon the most remarkable of these changes, viz., its great decrease in acute affections.

D. CASEIN AND EXTRACTIVE MATTERS.

In the physiological state, these substances may vary considerably. The casein does not invariably increase in quantity with the age of the milk. In repeated analyses, made upon the milk of one individual, we frequently obtained numerical proportions analogous to the mean of the whole period of lactation. We must, therefore, admit, that the growth of the infant is not always dependent upon the nutritive materials afforded by the milk.

In acute diseases, there is almost always an increase of the casein. In chronic diseases, on the contrary, its proportion falls below the mean of health.

E. THE BUTTER.

It is here that we meet with the greatest variations, as well in health as in disease. An opinion was long entertained, that the proportions of butter and casein increased and decreased simultaneously; this, however, is not the case, and such an opinion ought no longer to be entertained.

It is more especially under the influence of certain diseases, that the proportion of butter is liable to vary. In acute and chronic affections, it invariably increases. The reverse, however, takes place in syphilis. Having already insisted upon this point, we shall say no more.

F. THE SALTS.

The following table shows the mean composition of the salts in 1000 parts of milk.

A portion insoluble in water, but soluble in acids .	0.775	Carbonate of lime . . .	0.069
		Phosphate of lime, with perhaps a small proportion of other salts .	0.706
A portion soluble in water . . .	0.225	Chloride of sodium	0.098
		Sulphate of Soda	0.074
		Other salts	0.053
Total .	1.000		

From an examination of the weight of the salts, in health and disease, we draw the following conclusions:

In the healthy state, the representative number of the salts merely varies by a few hundredths, from the first to the eighteenth month of lactation.

In disease, the proportion of salts has a tendency to increase; this is due to the decrease of the watery part of the milk.

We have here a remarkable fact to notice, viz., the extraordinary increase of the salts, under the influence of syphilitic disease, whether treated by mercurials or not.

SECT. V.—Of the Choice of a Nurse.

We cannot close this chapter more suitably, than by stating the opinions of MM. Vernois and Becquerel upon this important subject.

That which ought more especially to influence the choice of a nurse, is the combination of those chemical characteristics of the milk, which approach nearest to the physiological standard, as given above.

By means of the following table, the difficulty often attendant upon the choice of a proper nurse, will, we conceive, be greatly removed, inasmuch as it affords a standard of comparison, by which to test the eligibility of any given specimen of milk.

Table, shewing the indications afforded by an Analysis of the Milk, as bearing upon the choice of a nurse.

Indications afforded.	Age of the Nurse.	Age of the Milk.	Constitution.	Primip. or Multip.	Breasts.	Hair.	Menstruation.	Diet.	Quantity of Milk.	Health of Infant.
	From	Months								
1. By the specific gravity	15 to 40	3 to 4	Robust.	Multip.	Little developed.	Brown.	Suspension.	Good.	Abundant.	Good.
2. By the weight of water......	20 to 25	4 to 5	Ditto.	Ditto.	Ditto.	Ditto.	Ditto.	Moderate.	Scanty.	Ditto.
3. By that of the solid matters	20 to 35	4 to 5	Ditto.	Ditto.	Ditto.	Ditto.	Ditto.	Good.	Ditto.	Ditto.
4. By the proportion of sugar	20 to 25	3 to 10	Ditto.	Ditto.	Ditto.	Ditto.	Coexistence, or suspension.	Ditto.	Ditto.	Ditto.
5. By that of casein	20 to 25	4 to 6, 10	Feeble.	Either.	Well developed.	Ditto.	Ditto.	Ditto.	Abundant.	Ditto.
6. „ „ butter	20 to 25	4 to 5	Robust.	Multip.	Little developed.	Ditto.	Ditto.	Ditto.	Ditto.	Ditto.
7. „ „ salts...	20 to 25	2 to 5 11 to 12	Ditto.	Either.	Well developed.	Ditto.	Ditto.	Ditto.	Scanty.	Ditto.

ARTICLE VII.

OF THE TEARS.

The tears are a fluid secreted by the lachrymal glands. This fluid is clear, limpid, and contains a small proportion of solid constituents. The difficulty of collecting a sufficient quantity of this secretion, together with, perhaps, the slender amount of scientific interest which the subject possesses, are no doubt the reasons of our possessing no very accurate analysis of this fluid.

When examined under the microscope, the tears present epithelial cells, and a few mucous globules floating in a clear limpid fluid. Their taste is somewhat saline; this is attributed, by Simon, to their being always mixed with some of the cutaneous exhalation from the skin of the forehead.

Fourcroy and Vauquelin are the only chemists who have given a good analysis of the lachrymal fluid. They found its composition to be identical with that of the aqueous humour. The proportion of solid matters is about 1 per 1000; it consists chiefly of chloride of sodium, together with a yellowish coloured animal substance, not entirely soluble in water. This substance may possibly be secreted by the Meibomian glands. In addition, the lachrymal fluid contains a small quantity of mucus.

The secretion of the Meibomian glands appears to be a mixture, we might almost say a combination, of mucus and fatty matters; we may add, however, that but little is known respecting it.

CHAPTER IV.

OF THE SECRETED PRODUCTS OF THE MEMBRANES IN GENERAL, AND OF THE CHANGES TO WHICH THESE PRODUCTS ARE LIABLE.

We propose to consider, in this chapter, the secretions derived from the mucous and serous membranes, as also from the skin. These we shall investigate both in a physiological and pathological point of view, endeavouring, at the same time, to shew the advantages which practical medicine may derive from such investigations, and how far the torch of modern chemistry may throw a light upon problems hitherto unsolved.

ARTICLE I.

OF THE MUCOUS MEMBRANES.

The natural secretion of the mucous membranes, is the fluid called mucus.

This mucus is susceptible of certain modifications, thus giving rise to various products.

We shall first examine the mucus and the changes of which it is susceptible, and then pass on to the alterations of the principal mucous membranes, together with their functional peculiarities.

Sect. I.—Mucus.

Mucus is the secreted product of a mucous membrane, whether in health or disease; there is, therefore, a healthy and a morbid mucus. Between these two varieties there exists, however, no very definite or clearly marked distinction; and we only pass by insensible gradations from the former to the latter. Here, therefore, do we meet with the first obstacle requiring to be removed, and this justifies us in considering separately healthy and diseased mucus.

A. HEALTHY MUCUS.

It is somewhat difficult to procure healthy mucus, in quantity sufficient for the purpose of analysis; hence we are often obliged to be content with that obtained from the mucous membrane of the nostrils, and sometimes, but more rarely, with that of the intestines.

Several interesting communications have been published respecting the composition of mucus. These are to be found in the works of Henle, Simon, Vogel, Gruby, and others. The following is the actual state of science relative to the secretion in question.

Healthy mucus is a viscid transparent product, of an opaline, whitish colour; its reaction is alkaline. When evaporated in the open air, or dried in a stove, at a temperature of 40° and upwards (centigrade measurement = 105° Fah.), it is capable of reabsorbing water, and of thus regaining its pristine qualities. Fresh mucus when thrown into water, conducts itself somewhat differently, according to its origin.

Thus the nasal and bronchial mucus float on the surface for some little time, but, at last, sink. This is due to the presence of bubbles of air, with which the mucus is impregnated, and which thus render it lighter than the water. That derived from other membranes sinks far more rapidly.

Physical Characteristics.—Mucus may be regarded as composed of: 1. A transparent fluid, holding a certain number of principals in suspension; and 2. Of suspended corpuscles, which admit of being examined under the microscope. These corpuscles, or cells, are of two kinds:

1. Epithelial cells, which present themselves under the form of elliptical discs; their diameter has been thus ascertained by M. Gruby.

Long diameter varying from 0.013‴ to 0.033‴.

Short diameter varying from 0.010‴ to 0.016‴.

Their surface is often irregular, as if crumpled. These cells contain nuclei of elongated form and granular appearance; they are distinguishable by their darker colour, and are more numerous than the next variety.

2. Mucus globules or corpuscles. These, as just stated, are less numerous than the preceding, in healthy mucus; their diameter varies from 0.003‴ to 3.007‴. In shape they are either round or oval, their outline is clear and well-defined, their colour pale grey; the nucleus, which is occasionally visible, may be rendered more distinct by the addition of water.

The presence and form of these two kinds of corpuscles, favours the opinion of Henle, who considers healthy mucus as being the product of the desquamation of the epithelium of mucous membranes; this desquamation occurring constantly in health.

Besides these two varieties of corpuscles, we find, on examining mucus under the microscope by means of a strong light, that it often presents a granular appearance. This is regarded as indicative of the approaching precipitation of the *mucine,* a principle of which we shall presently speak.

The fluid in which these corpuscles are suspended, is composed of water holding in solution a certain number of chemical constituents, of which we shall likewise treat hereafter.

CHEMICAL CHARACTERISTICS.—Mucus is chiefly composed of water, holding in solution the following substances:

1. *Mucine.*—This, which gives to the mucus its viscidity and special characteristics, is held in solution by means of free soda.

2. It has been stated, that traces of albumen might be detected in mucus: we have, however, repeatedly ascertained that this elementary principle is only met with in disease.

3. Free soda, lactate of soda, and chloride of sodium.

4. Incineration, moreover, affords traces of phosphate of lime and silica.

5. Extractive matters.

Microscopic examination and chemical analysis, readily explain the following reactions:

If, to healthy mucus there be added a certain quantity of water, alcohol, or diluted acid, it becomes turbid and opaline. This is due to the fact, that the water and alcohol, by diminishing the alkaline reaction caused by the soda, precipitate the mucine. Under the microscope, this coagulation is revealed by the formation of a semi-opaque membrane, of a fine granular, cloudy aspect.

The effect of certain reagents upon the mucus globules, as seen under the microscope, is as follows:

The epithelial cells being exposed to the action of water or of diluted acids, their external envelope becomes paler and more transparent.

It disappears under the influence of concentrated acids or alkalies.

Under the influence of diluted oxalic, acetic, and tartaric acids, the mucus globules lose their granular appearance; they become round and transparent, while their nuclei are rendered more apparent. If the action of the reagent be continued, the external capsule disappears, the nuclei are isolated, and end by separating themselves into three or four granules. All globular appearance is now lost.

The diluted mineral acids do not affect the external covering of these corpuscles. Solutions of the fixed and volatile alkalies render it transparent, and, at last, dissolve it. Diluted solutions of the carbonates of these alkalies produce similar effects, but less readily.

With respect to each mucous membrane in particular, the mucous secretion varies but little; this will be seen by a rapid analysis of its chief characteristics, as observed in different localities.

a. Nasal mucus is constituted, in health, by an almost transparent gelatinous mass, containing epithelial cells and mucus corpuscles. It is insoluble in water, but, after a time, loses a small quantity of mucine, the water containing which, becomes turbid on the addition of acetic acid. This mucus, when dried at a gentle heat, regains its properties upon the addition of water. The effect of reagents is identical with that already alluded to, when treating of mucus in general. We may state here, however, that caustic alkalies render it thick and rugous, and, at last, produce complete solution.

b. The broncho-pulmonary mucus resembles, in every respect, that derived from the nostrils.

c. The intestinal mucus is a yellowish gelatiniform substance, containing epithelial cells and numerous mucous corpuscles. When thrown into water it sinks, and a small proportion of the mucine is dissolved.

d. The mucus derived from the gall bladder presents nothing special.

e. The same may be said of the vesical mucus.

B. OF THE MUCUS IN DISEASE.

When a mucous membrane is irritated or inflamed, an increased secretion of mucus, together with a change in its quality, is the almost invariable result. Before treating of these modifications, it may be necessary to state, that we speak merely of irritation or inflammation unattended with ulceration.

When a mucous membrane is inflamed, its secretion increases in quantity, and is more fluid than usual; at a subsequent period, it becomes more opaque. The microscope shews, that the epithelial cells are less numerous than in health, while the mucus globules are much more so.

At this stage, the mucus contains a small quantity of albumen and fatty matters, especially of cholesterine, which did not exist before. Its reaction is markedly alkaline.

At a subsequent period, the mucus becomes opaque, yellow, and viscid. The microscope reveals a small number of epithelial cells, and a large number of mucous corpuscles. There are found, moreover, some larger globules or cells, of rounded form and yellowish white colour, the diameter of which has been stated by Gruby to be eight times that of the blood globules. These cells are composed of a transparent capsule enclosing a second, in which there exists, for the most part, a nucleus, about equal in size to a blood globule. These large cells are remarkably affected by water, on the addition of which, the external covering bursts, the internal one remaining intact, and the large molecules which it contains becoming agglomerated on its internal surface. These cells are not all alike: thus, the nucleus may be wanting, as also the internal capsule, in which case we find merely a single envelope containing molecular granules.

These large cells described by Gruby, have been likewise pointed out and carefully examined by Simon and Henle.

Chemical analysis reveals important changes in diseased mucus. There is, in the first place, more albumen present than at the commencement of the inflammation. The fatty matters, partly composed of cholesterine, are likewise more abundant. Lastly, according to Simon, there is found pyin; this principle, however, has not been isolated, and our own analyses do not confirm the truth of this assertion.

The above description applies equally to the different varieties of morbid mucus. Thus, in nasal mucus, microscopic examination reveals a few epithelial cells, mucus corpuscles and a large number of vesicles, of the species just described.

The following analysis is given by Simon:

Water	880	
Solid matters	120,—thus constituted :	
Fat, containing cholesterine		6.
Cheesy matter, with pyin and mucus in solution		13.2
Extractive matters, with lactate of soda and chloride of sodium		12.
Albumen, cells and coagulated mucus		84.
		115.2

The mucus resulting from blenorrhagic ophthalmia and blenorrhagia, in both male and female, has been minutely examined by Simon. It is yellowish in colour, opaque, and of moderate viscidity. It sinks in water, forming flakes, which when shaken lose their colour, but communicate a yellowish tinge to the liquid. This variety of mucus contains a great number of the large yellow corpuscles formerly mentioned, the majority of these having a central nucleus.

The vaginal mucus has been carefully investigated by Gruby, both before and after delivery, with the following results :

Before delivery, the vaginal mucus merely contains a few epithelial cells, and a somewhat larger amount of mucus corpuscles.

Shortly after parturition, there are found the large mucus vesicles containing molecular granules. With these are intermingled numerous blood globules.

On the second day, the mucus is less dense, and the blood corpuscles less numerous. The vesicles now begin to shew signs of a central nucleus.

From the third to the tenth day, these vesicles increase in number, while the blood globules gradually disappear.

At about the eleventh day, the mucus regains its natural white colour ; while the microscope detects in it, round, whitish vesicles, with molecular granules, but without a central cell.

Dysenteric mucus has likewise been examined by Gruby ; he states, that it contains mucus corpuscles and blood globules.

Bronchial mucus has been carefully examined by Simon, who found in it, as in other varieties of morbid mucus, a few epithelial cells, mucus corpuscles, and large vesicles.

The following analysis is given by this author :

Water	94.75	
Solid matters	58.25,—thus constituted :	
Fat, with traces of cholesterine		5.01
Aqueous extract, with chloride of sodium and lactate of soda		11.09
Alcoholic extract		6.95
Cell, mucine and albumen		34.80

C. PURULENT MUCUS, PROPERLY SO CALLED.

Whenever a mucous membrane is stripped of its epithelium, or becomes the seat of ulceration, the part affected ceases to secrete mucus, this product being replaced by pus. The pus thus formed, becomes mingled with mucus produced by the irritation of that portion of the membrane which remains sound, and there results a compound, which is simply a mixture of pus and mucus in varying proportions, and consequently possesses the properties peculiar to each of these morbid products.

If we suppose, for a moment, the mixture to be composed of equal parts of pus and mucus, the following description is applicable:

Purulent mucus, or muco-pus, when thrown into water, sinks more rapidly than pure mucus, whether healthy or diseased. This is due to its less degree of viscidity, and to the absence of air bubbles. It frequently separates into parts, one of which sinks rapidly in the form of irregular, whitish, friable clots,—this is the pus; the other floats for some time on the surface of the water, in the form of a cloud,—this is the mucus.

Microscopic examination shews:

1. A few epithelial cells;
2. Mucus corpuscles;
3. Numerous pus globules.

These last, when brought into contact with water, rapidly undergo the following changes:

They swell and increase in size; the capsule becomes transparent and vesicular; its granular appearance is lost, and a nucleus may be perceived containing, often, two or three nucleoli. If the contact be prolonged, the capsule bursts, and the nuclei escape. These modifications are, in fact, similar to those which take place, under similar circumstances, with regard to the mucus corpuscles; the latter merely requiring longer immersion in water.

4. Large vesicles, characteristic of morbid mucus.

Chemical analysis shews purulent mucus to be composed of:

1. A much smaller proportion of mucine than healthy or morbid mucus;
2. A proportion of albumen, greater than is met with in diseased mucus, the product of a non-ulcerated membrane;
3. A certain amount of fatty matter, and more especially of cholesterine;
4. Pyin.

The presence of these different substances explains the following reactions:

The water into which purulent mucus has been thrown, is sometimes colourless and transparent; at other times, it is somewhat yellowish in colour, viscid, and rendered slightly turbid on the addition of acetic acid, which coagulates the mucine. Nitric acid and heat produce a similar effect, but by coagulating and precipitating the albumen; whilst, in the case of mucus, the proportion of albumen is so small, that no appreciable quantity is dissolved by the water; and hence, in the majority of instances, the absence of coagulum on the application of heat and nitric acid.

These characteristics appear to vary, in proportion as the mucus or pus predominate.

In the former case, it might be difficult to distinguish purulent from non-purulent mucus, without having recourse to chemical investigation, so as to determine the increased proportion of albumen, the large amount of fatty matters, and the existence of pyin, should such a principle actually exist.

In the latter case, the substance would bear so close a resemblance to pus, as to render the distinction comparatively easy.

We may sum up the history of the mucus and its modifications in the following table:

Normal mucus.	Morbid mucus.	Purulent mucus. Muco-pus.
Under the microscope.	*Under the microscope.*	*Under the microscope.*
1. Numerous epithelial cells.	1. Scanty epithelial cells.	1. Scanty epithelial cells.
2. A few mucus cells.	2. Abundance of mucus cells.	2. Mucus cells.
3. A fine granular appearance, due to incipient precipitation of the mucine.	3. Yellowish globules, called pus globules, larger than the preceding.	3. Numerous pus globules, rapidly modified upon contact with water.
	4. A granular appearance, due to the mucine.	
Matters held in solution by the water.	*Matters held in solution by the water.*	*Matters held in solution by the water.*
1. Mucus in tolerable quantity.	1. Mucine in tolerable quantity.	1. A very small quantity of mucus.
2. Saline matters: Free soda. Lactate of soda. Chloride of sodium. Phosphate of lime.	2. Sometimes a small quantity of albumen.	2. A much larger quantity of albumen.
3. Extractive matters soluble in water.	3. A small but appreciable quantity of fatty matters.	3. Fatty matters in abundance.
4. A trace of fatty matter.	4. The same salts and extractive matters.	4. The same salts and extractive matters.

Sect. II.—Of False Membranes.

Besides healthy and morbid mucus, there are other products of diseased action, not unfrequently formed on the mucous surfaces; these are denominated false membranes, and are entirely different from those formed in the serous cavities of the body.

Each mucous surface may be the seat of false membranes. They occur in the following order, in point of frequency: *a.* In the nostrils; *b.* In the mouth, pharynx, stomach, and intestines; *c.* In the larynx, trachea, and bronchi; *d.* In the bladder and neck of the uterus.

These false membranes when fully formed, are composed of a greyish or yellowish substance resembling coagulated white of egg, spread out in thin layers. Their extent and thickness vary considerably. Those which are formed at the close of the disease are thinner and less consistent, they frequently present irregularities, and do not completely cover the subjacent mucous surface. The false membranes, when once deposited on the surface of the epithelium (for it is very certain that this latter is not destroyed), are destined to be eliminated in those cases where the disease terminates favourably. This process of elimination runs a particular course, and constitutes a phase of the disease. In order that it may take place, the nature of the mucous secretion must undergo a change,—the membrane furnishing a certain quantity of healthy mucus, instead of a false covering. It is, in fact, this mucus which, when secreted in sufficient amount, gradually detaches the false membrane, destroys, and finally eliminates it. In the buccal cavity and in the pharynx, false membranes, if not rapidly thrown off, become black and fœtid, and have not unfrequently been mistaken for gangrene.

What is the nature, we may ask, of these false membranes? Are they formed of coagulated albumen or fibrin? Microscope examination is here of no avail. All micographers agree in stating, that the false membranes formed on mucous surfaces are unorganized. No cells can be detected; in a word, we see nothing but an amorphous mass, without a trace of organization. In a chemical point of view, this substance has not been investigated, but we conceive that such investigation would avail nothing, inasmuch as the reactions of coagulated albumen and of fibrin are absolutely identical.

There is, however, one reason for regarding these false membranes as composed of coagulated albumen: it is this. The false membranes formed on the serous surfaces are evidently composed of fibrin; this admits of no doubt. They are, moreover, susceptible of organization, which, to a certain degree, indeed, they all undergo. Why is not this the case with false membranes formed on the mucous surfaces?

If we admit, however, that these latter are actually composed of fibrin, the following arguments might possibly explain this difficulty of organization:

1. False mucous membranes are secreted by a tissue, whose organization is very complex, and to the perfection of which, the pseudo-membranous product is unable immediately to attain; while, on the contrary, the structure of a serous membrane is very simple, being in fact a species of cellular tissue, the organization of which is almost identical with the primitive structure of fibrin.

2. False mucous membranes being in contact either with air, aliment, or urine, etc., etc., there is here a special condition which prevents them from becoming duly organized.

3. It is not absolutely necessary that every fibrinous production should become organized. Thus, pus is evidently an albuminous fluid, in which the fibrin has undergone a special transformation, in virtue of which it constitutes the pus globule. But these globules can undergo no further organization; they remain as pus globules, and must be eliminated.

4. False membranes are formed in the bladder, in that form of *cystitis* which is produced by cantharides. Here, along with these false membranes, there is found, in the urine, a certain quantity of albumen in solution. The presence of this substance has given rise to two opinions. If we admit the existence of cystitis produced by cantharides, it is probable

that that secreted by the vesical mucous membrane, is a fibrinous serosity, which immediately separates into two parts, viz., the albuminous serosity, which remains in solution, and the fibrin, which coagulates and forms false membranes, absolutely identical with those of mucous membranes in general. If, on the contrary, we admit, with Bouillaud, the existence of an albuminuria produced by cantharides, and this we conceive to be far more probable, the explanation is simple enough. Such are the grounds upon which we may assert the fibrinous nature of these false membranes.

We shall now take up the reverse side, and enumerate the reasons for supposing that these false membranes are formed of coagulated albumen.

1. Their want of organization;

2. Their being analogous, in appearance and properties, to coagulated albumen;

3. The absence of albuminous serosity on the surface of all the mucous membranes, except that of the bladder; so that it has been reasonably asked, whether the albumen found in cases of cystitis produced by cantharides, did not proceed from the kidneys.

In presence of such arguments, we hesitate to pronounce a decided opinion, and can merely say: That the false membranes formed on the mucous surfaces are the result of a specific inflammation, which, more especially at its commencement, secretes an amorphous fibrin, in such a molecular condition as to be unable either to undergo ulterior organization, or even to be transformed into pus. The pus and mucopus with which they are found mingled, are not the result of a transformation of these membranes, but the secreted product of the specific inflammation of the mucous surface in its later stages, which thus serves to eliminate the morbid secretion first thrown out.

The view here adopted respecting false mucous membranes, obliges us to quote the opinion of Vogel on this subject. In his treatise on *Pathological Anatomy* (page 519) he says: "In "certain rare cases of very acute inflammation, coupled with,

" in all probability, an excess of fibrin in the blood, the exuded " plasma coagulates on the surface of the mucous membrane, " and thus forms a membranous layer, as in croup, diphtheritis, " subacute enteritis, and especially in dysentery. These false " membranes are generally eliminated, unless the patient succumb prematurely. I have never seen them become organized, nor even transformed into pus corpuscles or granular " cells; all that I have ever seen were amorphous."

Vogel, usually so exact, has here expressed an opinion which we conceive to be at variance with facts. It is not by reason of its intensity that the inflammation of a mucous surface produces the secretion of a false membrane, but in virtue of a particular disposition, which we may call *specific*. In a word, it is the specific character of the inflammation which gives rise to the pseudo-membranous secretion. False membranes are often seen to form in connexion with a very moderate degree of inflammation, just as certain acute and intense inflammations may occur without any such formation.

There is another peculiarity connected with the false membranes formed on mucous surface, viz., that they are never found to contain microscopic algæ or fungi.

SECT. III.—Of Thrush (Muguet).

There is another morbid product secreted by the mucous membranes, which has given rise to many discussions, and has been variously interpreted.

In young debilitated children, congregated in large numbers, badly nourished, and exhausted by diarrhœa; and likewise in adults, towards the close of an exhausting disease, such as typhoid fever, chronic dysentery, phthisis pulmonalis, cancerous affections, Bright's disease, etc., we often find on the mucous membrane of the mouth, a whitish pellicle, of a pultaceous creamy consistence, and but slightly adherent to the subjacent surface. This formation, which in some rare cases is likewise found in the intestines, has been called muguet or thrush.

Three different opinions have been entertained, respecting the nature of this pathological production.

1. The majority of authors regard it as a pseudo-membranous product, in every respect analogous to the false membranes previously described. They do not attempt to explain its nature, or whether it be albuminous or fibrinous; it is enough for them, that it is a false membrane.

Such a view, however, cannot be much longer maintained. The chemico-physical characters of this production, clearly shew, that it is neither albuminous nor fibrinous.

2. Others conceive that the inflamed mucous surface secretes a false membrane, in which are subsequently formed microscopic fungi. This opinion comes nearer the truth.

3. The inflamed mucous membrane is supposed to create a layer of mucus, loaded with epithelial cells, the characteristics of which are analogous to those of ordinary mucus. In proportion as this mucus is secreted, every portion of it developes a large number of microscopic fungi, which constitute the characteristic feature of the disease. It is this fungus to which M. Robin has given the name of *oidium albicans.*

Fully adopting this opinion, which, in the present state of science, cannot, we conceive, be contested, we shall here quote the conclusions arrived at by M. Robin in his excellent work.*

" 1. The pseudo-membranous appearance which constitutes " the anatomical element of this disease, is not really produced " by false membranes, but, in a great measure, by the spores " and tubular filaments of a vegetable, mingled with the " epithelial cells, of the buccal mucus. These divers ele- " ments are maintained in contact, by the viscid liquid secreted " by the lining membrane of the mouth.

" 2. The parasitic plant itself, is composed of tubular fila- " ments, much ramified. The borders of these filaments are " distinct; the cavity of the cells of which they are formed, " contains some molecular granules, or, occasionally, from two " to four smaller cells, very pale and of ovoid shape. These

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* *Natural History of the Parasitic Vegetables found in Man and Animals*, p. 502.

" filaments, or articulated tubes, spring from a spore, which " shoots forth a tubular prolongation; this spore retains its " form at whatever period of development the parasitic plant " may have arrived. Its free extremity is usually formed by a " short bulky cell, which likewise becomes a spore; it is often " preceded by several ovoid cells, joined together like a chaplet; " these cells are so many spores in process of formation.

" The spores are spherical or somewhat elongated, with clear " dark edges and a bright centre. They contain a fine dust, " and, not unfrequently, one or two moveable molecular " granules. In spores that have germinated, these granules " are constantly being displaced.

" 3. The tubular filaments are interlaced in every direction; " the spores, collected together in groups, adhere strongly to " the epithelial cells, whether isolated or imbricated, and either " cover them entirely, or constitute merely rounded masses on " portions of their surface. From such masses may sometimes " be seen to project, a tubular prolongation that has just ger- " minated.

" 4. This parasitic plant, and the plates which it forms, " cannot be regarded as a constant symptom of disease, nor " indeed as a disease; it is developed whenever the mucus " undergoes such a change as to permit of its growth; and " observation shews, that if this change be ordinarily consecu- " tive to some mucous inflammation or other disease, it may " likewise be developed under the influence of various other " circumstances (insufficient nourishment, etc.), or even without " any apparent cause."

Sometimes, along with this fungus, there is developed an alga, to which M. Robin has given the name of *cryptococcus cerevisiæ;* but it is quite an accidental production, and of far less importance than the *oidium albicans.*

SECT. IV.—Of the Respiratory Apparatus.

It is not our purpose here to undertake a chemical history of the respiration. We shall merely present a slight sketch of the subject, for which sketch we are mainly indebted to MM. Robin and Verdeil.

Atmospheric air contains, as is well known, 21 parts of oxygen and 79 of nitrogen, or, more strictly speaking, 20.90 of the former and 79.10 of the latter gas, by volume; and by weight, 23.10 of oxygen and 76.90 of nitrogen, from $\frac{4}{10000}$ to $\frac{6}{10000}$ of carbonic acid, variable proportions of watery vapour, and traces of hydrogen, ammonia, iodine, etc. The oxygen, nitrogen, and carbonic acid are alone connected with the phenomena of respiration, and, therefore, we shall confine our attention exclusively to them.

Oxygen.—The air introduced into the lung loses during the act of inspiration, from 4 to 6 per cent. of its original volume. This loss takes place at the expense of the oxygen, which is now represented by the numbers 15 or 16. A knowledge of this fact admits of our readily ascertaining the quantity of oxygen contained in the lung. Thus, after an ordinary expiration, the lung, in a state of repose, contains $15\frac{18}{25}$ cubic inches of gas; and after forced expiration, only $9\frac{7}{25}$ cubic inches. The lung, therefore, when at rest, and immediately after an ordinary expiration, contains from 3 to $3\frac{1}{3}$; and after forced expiration, from about $1\frac{1}{4}$ to $1\frac{2}{3}$ cubic inches of oxygen.

More oxygen is absorbed when the respiration is accelerated than when it is of natural frequency. But when once the proportion of oxygen absorbed, reaches 10 per cent., no further increase takes place.

The proportions, by weight, may be thus represented: 0 grammes 094 to 0 gr. 107 of oxygen in ordinary expiration; and 0 gr. 045 to 0 gr. 050 in forced expiration. Hence it follows, that the amount of oxygen usually left in the lung after tranquil expiration, amounts only to about two-thirds of that contained in arterial blood, and to about a fourth of that existing in the whole mass of the blood.

What then, may we ask, becomes of the oxygen which thus disappears in the lungs?

We admit, with the majority of modern physiologists, that the oxygen is absorbed by the blood globules, from which it expels a quantity of carbonic acid, equivalent, in man, to about a fourth. There is, however, no chemical connexion between these phenomena; and the oxygen, as soon as it is taken up by the globules, enters into combination with various organic matters, in order to form new compounds, which play an important part in the organization of the body. Thus, the combustion of hepatic sugar, the formation of urea, and even that of the carbonic acid, hereafter to be exhaled, together with certain other phenomena, acknowledge, in all probability, no other origin. We ought, however, to state, that, according to MM. Robin and Verdeil, who have carefully investigated this subject, we know nothing, either of the organic substances with which the oxygen combines, or of the nature of those immediate principles which it is capable of forming with them. Lastly, we are entirely ignorant of what takes place in the interval between the absorption of the oxygen by the globules, and the escape of the carbonic acid from these same globules.

In the pathological state, there are, probably, considerable variations in the amount of oxygen absorbed. It has been shewn, that the carbonic acid may so far vary, that, instead of the quantity exhaled being from 3 to 5 per cent., it may fall as low as 1 and rise to 8 per cent.; but, as there is in health, a certain ratio between the liberation of carbonic acid and the absorption of oxygen, it is probable that a similar ratio may exist in cases of disease. Science, however, possesses no fact enabling us to determine the nature of these pathological changes, which, as yet, therefore, we can but speculate upon.

Nitrogen.—Nitrogen, as a portion of the atmospheric air, enters the lungs together with oxygen. The expired air usually contains, in warm-blooded animals, a quantity of nitrogen somewhat larger than, or at least equal to, that of the inspired air. Hence it follows, that animals yield a small portion of nitrogen to the atmospheric air, which portion they must have necessarily derived from the introduction of fluid or solid aliment. When animals are deprived of food, the reverse takes place: they abstract from the air a small proportion of nitrogen.

The following calculations have been made by MM. Robin and Verdeil.

After tranquil expiration, there remain in the lungs $15\frac{18}{25}$ cubic inches of gas, and consequently 12· cubic inches of nitrogen, or by weight 0 grammes 0487; and after forced expiration, $9\frac{7}{25}$ cubic inches, of which $7\frac{9}{25}$ are nitrogen; by weight, 0 gr. 0290.

This nitrogen exists, while in the lung, in combination with oxygen, carbonic acid, the vapour of water, and the produce of the pulmonary exhalation.

The presence of nitrogen in the blood does not indicate its participation in the composition of that fluid; it merely shews that it is one of the conditions of the mutual interchange which takes place between the internal and external gases.

We are not cognizant of the variations of which the nitrogen is susceptible, under the influence of age, temperament, constitution, or disease. In the latter case, such variations must in all probability exist; for we know that animals that have been for some time deprived of food, abstract a small quantity of nitrogen from the inspired air, which indicates that, in all probability, the proportion of this gas existing in the blood may vary under certain circumstances.

The nitrogen found in the lung is derived from the atmospheric air, a small proportion of it, however, comes from the blood; the quantity rarely exceeding the $\frac{1}{100}$th of the oxygen consumed. There is, therefore, a constant interchange between the pulmonary nitrogen and that of the external air, on the one hand; and, on the other, between this latter and the nitrogen of the blood.

We know not what are the immediate principles furnishing the nitrogen exhaled by the blood. In all probability, the solid matters of the food contribute a portion.

Carbonic Acid.—This gas, the proportion of which in the inspired air does not exceed $\frac{5}{10000}$ to $\frac{6}{10000}$, is found in large quantity in the expired air.

The carbonic acid existing in the blood and more especially in the globules, in a state of solution, is displaced and exhaled upon the introduction of another gas. This takes place through the instrumentality of the respiratory act.

The proportions of carbonic acid are thus determined by MM. Robin and Verdeil:

Knowing, on the one hand, that the mean amount of air contained in the lung is about $15\frac{18}{25}$ cubic inches after tranquil expiration, and $9\frac{7}{25}$ cubic inches after forced expiration; and, on the other, that this air contains from 3 to 5 per cent. of carbonic acid, we draw the conclusion, that there exists in the lung, after ordinary expiration, from $\frac{14}{25}$ths to 1 cubic inch, and after forced expiration, from $\frac{7}{25}$ths to $\frac{16}{25}$ths of a cubic inch.

The amount of carbonic acid exhaled and of oxygen absorbed, depends upon the nature of the aliment consumed. It varies but little in animals similarly fed. The smallest exhalation of carbonic acid is met with in those fed entirely on meat, and the greatest, in those kept on vegetable diet. The frequency of inspiration, and muscular exercise, increase the proportion of oxygen absorbed, and consequently the amount of carbonic acid exhaled.

The carbonic acid found in the blood is derived from three different sources:

1. From the globules, which possess an absorbing power considerably greater than that of water.

2. From the serum, which absorbs almost as large an amount as water.

3. From the bicarbonates.

The experiments of Lehmann shew, that the proportion of carbonic acid in the blood is 70 per 1000, if we merely employ agitation or other mechanical measures, and 300 per 1000 on the addition of an acid.

According to MM. Robin and Verdeil, we are cognizant of two sources of carbonic acid in the organism, and two classes of conditions upon which its formation depends: the first is the decomposition, in the lungs, of the carbonates and bicarbonates of the blood by the pneumic acid contained in these organs; the second is the disengagement of the carbonic acid by organized matters.

In spite of the ingenuity of the theory, founded upon the presumed existence of pneumic acid, and upon the important part which it plays in the chemical theory of the respiratory act, it is not as yet universally admitted. All we know is, that carbonic acid is a product of the organism, thrown out by men and animals into the surrounding media.

The carbonic acid exhaled escapes by the bronchial tubes. According to Burdach, there are 1172 grammes 50 of carbonic acid thus thrown off in the twenty-four hours; and according to M. Dumas, 1100 gr. 00. The skin exhales about 17 gr. 50 in the same space of time.

Putrefaction or decomposition is one of the conditions under which the exhalation of carbonic acid takes place. Thus, the instances quoted of the formation of this gas in the pleura, peritoneum, tunica vaginalis, and in abscesses, recognize no other cause. Nevertheless, in the cases of spontaneous generation of gas in the blood, quoted by Morgagni, Ollivier, Reyrolle, Gosselin, Malgaigne, and Durand Fardel, putrefaction did not exist. The same may be said of those cases in which gas appears to be generated in the blood, where death occurs under the influence of chloroform.

Before alluding to the important researches of MM. Andral and Gavarret, relative to the amount of carbon consumed in the economy, we shall state a few facts that have been ascertained concerning the variations of the carbonic acid in disease.

According to M. Doyère, in the algide stage of cholera, the proportion of carbonic acid falls to 20 or even 10 per 1000 of the expired air, and gradually rises to 20, 25, and even 30 per 100, in proportion as convalescence progresses.

According to MM. Harvier and Saint Leger, intermittent fever, scurvy, purpura, and the phlegmasiæ increase the proportion of carbonic acid gas; we must here, however, except pneumonia, pleurisy, pericarditis and those inflammatory affections which interfere with the functions of respiration and circulation. The carbonic acid diminishes in phthisis, variola, measles, erysipelas, roseola scarlatina, erythema, dysentery, chronic diarrhœa, typhoid fever, as well as during the suppurative process.

Hannover asserts, that women affected with chlorosis exhale more carbonic acid than those who are in good health. Individuals of either sex, suffering from phthisis, exhale much less than in health. Bronchitis has no influence upon the amount expired. MM. Andral and Gavarret presume, with justice, that the carbonic acid exhaled, arises from some combustion of carbon; and thus, without looking to the source of this carbon, or to the point at which combustion takes place, they calculate the amount of carbon consumed, by that of carbonic acid exhaled. We here subjoin a portion of their interesting and important memoir.

OF THE INFLUENCE OF AGE, OF SEX, AND OF CONSTITUTION, UPON THE EXHALATION OF CARBONIC ACID BY THE LUNG.

"From the age of eight years, at which period our re-"searches commence, up to the latest term of existence, the "amount of carbonic acid exhaled by the lung in a given "time, undergoes considerable variations, in accordance with "the age, sex, and constitution of the individual.

"Our experiments upon this point amount to seventy-five "in number, and have reference to seventy-two different in-"dividuals, of whom thirty-six were males and twenty-six "females.

"During the second period of childhood, *i. e.*, from the age "of eight years up to puberty, the amount of carbonic acid "exhaled by the lungs increases year by year. Like other "changes which occur in the organism at this period of life, "those which the pulmonary functions undergo, are constant "but progressive; so that the proportion of carbon consumed, "for instance, in one hour, increases gradually from 5 grammes, "as afforded by a child eight years of age, up to 8 gr. 7 by "one of fifteen years.

"In the two sexes, the phenomena are identical; the same "laws obtain, the same regularity of progression is observed. "The only difference consists in the quantity of matter exhaled. Of more vigorous organization than the female, and "consuming a larger amount of food, the male child likewise "consumes a larger proportion of carbon. Thus, in young "girls from eight to fifteen years of age, the quantity of carbonic acid exhaled by the lung in the space of an hour, "may be represented, as a mean, by 6 grammes 4 of carbon; "while in boys of a similar age it rises as high as 7.4 grammes. "The difference in favour of the male sex is, therefore, about "1 gramme (15 grains) of carbon per hour.

"At the commencement of puberty, the influence of sex "upon the functions of respiration establishes a still further "distinction between the male and female.

"In the male, the law of increase in the amount of carbonic "acid exhaled by the lungs, holds good from the age of fifteen "up to that of twenty-five or thirty; and, moreover, as soon "as puberty is thoroughly established, the exhalation of carbonic acid undergoes a still more marked increase. A child, "fifteen years of age, was found to consume 8.7 grammes of "carbon in one hour; and a lad, but one year older (after "puberty), 10.2 grammes in a similar space of time. This "quantity gradually increased up to 11.2 and 12.4 grammes, in "healthy males of from twenty to twenty-eight years of age. "Having attained its maximum of activity between the ages "of twenty-five and thirty, the exhalation of carbonic acid by "the lungs remains for some time stationary; and then, as "the individual approaches his fortieth year, it begins slowly "to decrease.

"These facts prove, that in man, the pulmonary exhalation, "after furnishing its product in increasing quantities, in proportion as the organism approaches its acme of perfection, "undergoes a simultaneous arrest in conjunction with the "latter.

"Already, indeed, from the twenty-fifth to the thirty-first "or fortieth years, do we notice less marked results produced "under the influence of age; we shall presently see, how, in "reference to the constitution of the individual, this may be "satisfactorily explained."

In the female, the sequence of phenomena is not the same as in the case of the male, for when the epoch of puberty has arrived and the uterus has become the seat of a periodical sanguineous discharge, so great an influence is exerted by it upon the economy, that the exhalation of carbonic acid no longer coincides with the progressive development of the rest of the organism, as is the case in man. From the first appearance of the catemenia, the amount of carbonic acid thrown off by the organs of respiration in a given time, ceases to increase and remains stationary as long as menstruation is duly performed. This important fact will be illustrated in the following manner.

A female child, thirteen years of age, was found to consume 6.3 grammes of carbon hourly; another girl, fifteen and a half years of age, and in whom the catamenia had not as yet appeared, consumed 7.1 grammes in the same space of time; whilst a third, also fifteen and a half years old, but in whom the menstrual discharge was fully developed, consumed only 6.3 grammes. A similar result was obtained in healthy subjects of twenty-six and thirty-two years of age, and likewise in a female aged forty-five, whose catamenia had always been perfectly regular.

Thus, in the adult female whose catamenia are regular, the proportion of carbonic acid exhaled by the lungs remains the same as during the second period of childhood, in spite of her increased organic development. The mean consumed being 6.4 grammes of carbon per hour, as in children of the same sex; in man, on the contrary, the mean, which is 7.4 grammes before the age of fifteen, rises to 11.3 grammes between the ages of fifteen and forty. In adult life, therefore, the male exhales by the lungs, about twice as much carbonic acid as the female: so great a difference cannot be entirely referred to the influence of a more robust constitution, and of more nutritious diet on the part of the male; and if, in the female, at the period of puberty, the pulmonary function ceases to obey the law of development which prevails in relation to the other parts of the organism, and remains stationary at an epoch when, in man, it is, for some time to come, liable to an increased and increasing activity, we must conclude, that the novel function, of which, at this age, the uterus has become the seat, plays an important part in that singular period of arrest, to which, at this period of female life, the exhalation of carbonic acid is subject, and from whence it results, that, in this particular at least, the female retains the respiration of the child.

At the decline of life, new modifications occur in the exhalation of carbonic acid; these differ in the two sexes.

In man, after the age of forty, the amount of carbonic acid exhaled by the lungs undergoes no further increase, but gradually diminishes in direct ratio with advancing years.

Between the ages of forty and sixty, this decrease is comparatively little marked, and some individuals, even at this age, retain all their pulmonary activity; in general, however, the results are below those which we have obtained at about the age of twenty-five. Thus, while the carbonic acid exhaled in an hour was represented, on the average, by 11.3 grammes of carbon between the ages of fifteen and forty, there were only 10.1 grammes between the ages of forty and sixty. At this period of life, therefore, the male already consumes 15 grains less of carbon per hour. After the age of sixty, the combustion of carbon continues to lose its activity, and gradually becomes more feeble, in proportion as the individual approaches the termination of his natural career.

In males whose age varies from sixty to eighty, the amount of carbonic acid exhaled by the lungs, is represented, on the average, by 9.2 grammes of carbon per hour.

Lastly, we have been enabled to investigate the phenomena of respiration in a man one hundred and two years of age. This individual, who was still able to walk about his room with the aid of a stick, and likewise to shave himself, had no other infirmity beyond the debility consequent upon his great age; the experiments were systematically conducted, and borne without fatigue, the respiration remaining normal and regular, at about the rate of twenty inspirations per minute, while the carbonic acid exhaled by the lungs in the space of an hour, was only represented by 5.9 grammes of carbon. At this late period of existence, then, we obtain results similar to those furnished by children of from eight to ten years of age.

We may now proceed to consider the exhalation of carbonic acid from the lungs, as it occurs in females, after the age of forty.

At this period of life, when the pulmonary functions of the male are about to lose a portion of their former activity, the female, whose first menstrual discharge coincides with an arrest of the exhalation of carbonic acid, now presents a sudden increase of this exhalation, from the moment at which the catamenia cease to make their appearance; in fact, the mean amount of carbon consumed in an hour, by women in whom the menstrual discharge appears regularly, was found to be 6.4 grammes; while it rose to 8.4 in women aged from thirty-eight to forty, and of whom some had entirely ceased to menstruate, while in others the discharge had become less abundant.

"If such be the influence of menstruation upon the exhalation of carbonic acid by the respiratory organs, it was but natural that we should endeavour to ascertain what becomes of this function, in those cases where pregnancy has produced a cessation of the catamenial flow. With this view, we have examined four pregnant women: one at two and half months, another at the fifth month, a third at seven and a half, and a fourth at eight and a half months. The amount of carbonic acid exhaled by the lungs in these four persons, gave a mean of 8 grammes of carbon per hour, and ranged between 7.5 and 8.4 grammes.

"In pregnant women, therefore, we obtain results exactly similar to those afforded by women in whom the catamenia are either about to disappear or have already done so. In the former, as in the latter, the moment the menstrual discharge ceases, the exhalation of carbonic acid by the lungs acquires renewed activity.

"After, however, having acquired its maximum in the female at the close of menstruation, the exhalation of carbonic acid again decreases, in proportion as the individual, after the age of fifty, approaches the natural term of existence, and from henceforward we find it regulated by the same laws as in the case of the male.

"Thus, while in non-menstruating women, of from forty to fifty years of age, the amount of carbonic acid given off in the space of an hour, rose to 8.4 grammes of carbon; the mean, between the ages of fifty and sixty, fell to 7.3 grammes, and to 6.8 grammes in women whose ages ranged from sixty to eighty; this being still, however, a larger proportion than was met with in menstruating females at the age of twenty-five. Lastly, in a woman aged eighty-two, we obtained but six grammes of carbon.

"Thus, whenever we make the human female an object of investigation, without the limits of the menstrual period, whether before its appearance, or after its cessation, we meet with phenomena, regulated by the same laws which obtain in the male; the only difference consisting in the amount of the exhaled products.

"The study of man at the different periods of his organic development, has shewn us, that the exhalation of carbonic acid by the lung bears a direct and constant ratio to the aggregate powers of the economy. The same harmony is found on passing to a consideration of individual cases, and on comparing, in this respect, the results afforded by experiment, and the constitution of different individuals of similar ages. It may be laid down as a general rule, that the greater the development of the muscular system, the larger is the proportion of carbonic acid exhaled in a given time. A few figures will suffice to demonstrate the truth of this proposition.

"A male child, twelve years of age and of moderately good constitution, consumed 7.4 grammes of carbon per hour; a young Savoyard of the same age, very robust and exceedingly well developed, consumed 8.3 grammes in the same space of time, or as much as children of fourteen years of age, but considerably less than those who have attained the period of puberty.

"The greatest exhalation of carbonic acid that we have met with at about the age of forty, was equivalent to 12.1 grammes of carbon per hour, and this was in individuals whose muscular development was most marked; and, on the contrary, in another, aged forty-five, of average height, in good health, but of an exceedingly slight muscular development, we found, as the result of four successive experiments, that the quantity of carbonic acid exhaled by the lungs in the space of an hour, was represented, on an average, by 8.6 grammes of carbon; the proportion of this latter, during the four experiments, ranging within the narrow limits of 8.5 and 8.8 grammes. At a more advanced period of life, we find an invalid, seventy-six years of age, and of very slender muscular configuration, consuming only six grammes of carbon in the space of an hour. This ratio between the quantity of carbonic acid exhaled by the lungs, and the muscular development of the individual, is still more strikingly illustrated by the following examples.

"Five persons, whose ages varied from twenty-four to twenty-eight years, of good constitution and average muscular development, exhaled per hour, a quantity of carbonic acid, represented by a mean of 11.5 grammes of carbon; the utmost limits being 10.8 and 12.4 grammes: while in a young man, twenty-six years of age, chosen from the same class of society, exposed to the same external influences, and leading a similar mode of life, but evincing an extraordinary degree of muscular development, the proportion of carbon consumed per hour, was found, as the result of two experiments, to be as high as 14.1 grammes. On questioning this individual, we found in his habitual mode of existence, certain indications of great activity on the part of the respiratory organs; thus, in order to breathe freely, he found it necessary to inhabit a thoroughly ventilated locality, nor could he, without much difficulty, remain for any length of time in a crowded assembly.

"In a man, sixty years of age, whose muscular development was at least equal to that of the individual just mentioned, we likewise observed a great exhalation of carbonic acid; it was represented by the consumption of 13.6 grammes of carbon hourly. A third individual, sixty-three years of age, having, also, every appearance of an athlete, afforded similar results; he consumed, in fact, 12.4 grammes of carbon per hour; whilst in persons of average muscular development, and of from fifty to seventy years of age, the mean consumption of carbon per hour is only 9.11 grammes, and never rises above 10.6 grammes.

" Lastly, in an old soldier, ninety-two years of age, who, in spite of his years, still retained a considerable amount of muscular development, and had, in early life, been remarkable for his physical force, the exhalation of carbonic acid was found to be, relatively speaking, considerable, inasmuch as it was represented by 8.8 grammes of carbon per hour.

" We see, moreover, that in these four exceptional individuals, the proportion of carbon consumed, although great, does not the less follow the invariable law of decrease with advancing years; and it is not improbable, that the man who, at the age of ninety-two, still consumed 8.8 grammes of carbon per hour, may have consumed, at a less advanced period of life, at least as much as the one of sixty, who consumed 13.6, or as the young man aged twenty-six, who consumed 14.1 grammes per hour.

An analysis of individual phenomena, as occurring in females, would lead to similar results; and, while taking into account the all powerful influence of menstruation, we shall invariably find, that the amount of carbonic acid exhaled by the lung, at a given period of life, bears a direct ratio to the physical force of the individual.

" On observing, that in man the proportion of carbonic acid increases gradually, from the age of eight up to that of twenty-five, *i.e.*, during the period of growth; we are naturally led to ask, whether the combustion of carbon be in direct ratio to the weight of the individual; and whether the variations in quantity, which we have met with, might not be explained by a simple difference of weight. Such a view, however, appears to us quite untenable, in face of the assemblage of facts just mentioned.

" In the first place, and as regards the female sex, this opinion cannot, we repeat, be maintained; for, on the one hand, a woman twenty-five years of age weighs much more than a child of from ten to fourteen years of age, and yet does not consume more carbon; on the other hand, the weight of the body does not necessarily increase at the close of the menstrual period, while we have seen, that the exhalation of carbonic acid invariably undergoes a marked increase at this period.

" If, now, we compare the adult female with the male, at a similar period of life, we shall see, that to explain, by difference of weight, the great discrepancy which exists between the amount of carbonic acid exhaled by one or the other sex, it would be necessary to admit that the male weighs about twice as much as the female: a conclusion evidently erroneous in the majority of cases, and capable in itself, of negativing the question under discussion.

" Let us, however, confine our investigations to the male sex, and endeavour to ascertain the consequences of admitting such a relationship between the weight of the individual and the amount of carbonic acid exhaled by the lungs. Between the ages of twenty and thirty, the males consumes a mean of 12.2 grammes of carbon per hour, whilst healthy individuals of from thirty to forty years of age only consume 10.5 grammes; it follows, therefore, that the latter must weigh less than the former, in the proportion of 86 to 100; while, on the contrary, experience teaches us that the reverse is generally the case. Lastly, we might ask, did the individual aged one hundred and two, of good stature and strongly developed osseous system, weigh less than a child ten years of age? Such an assertion would be utterly untenable, and yet we have seen that a smaller quantity of carbonic acid was given off by the lungs of this centenarian, than by those of a child ten years of age.

" It may be stated, that the aggregate weight of an individual bears a certain ratio to three different systems, the development of which is unequal, in relation to one another: viz., the osseous system, the adipose system, and the muscular system; whilst the exhalation of carbonic acid by the lungs occurs merely in connexion with one of these, the muscular system. Hence we see, that in some cases the increase of weight on the part of the body may actually prove an index of the activity of the pulmonary functions; but the relationship has nothing constant, and, in the great majority of cases, does not even exist.

"Here, likewise, presents itself, another question of great importance, and we may ask—do not the variations which occur in the quantities of carbonic acid exhaled by the lung in a given time, depend simply upon a difference in the capacity of the thorax, in the extent of the respiratory movements, and, consequently, in the volume of the expired air? An examination of this problem would lead us to speak of certain pathological facts, which might afford greater facility for its complete solution. Whilst, therefore, reserving for a subsequent memoir, the privilege of restricting within very narrow limits the influence of the above conditions; we shall content ourselves with here stating, that those variations which are constantly found to accompany the circumstances of age, sex, constitution, and menstruation, actually indicate some modification in the activity of those forces which, in the economy, preside over the combustion of carbon.

"From the facts collated in the memoir alluded to, we conceive it possible to draw the following conclusions:—

"1. That the quantity of carbonic acid exhaled by the lungs in a given time, varies according to the age, sex, and constitution of the individual.

"In the male, as in the female, this quantity depends upon age, and is independent of the weight of the person experimented upon.

"3. At every period of life, from the age of eight up to the utmost limit of existence, the male and female are distinguished by a difference in the amount of carbonic acid exhaled by the lungs in a given time. All things being equal, the male invariably exhales a larger quantity than the female. This difference is especially marked between the ages of sixteen and forty, at which period, the former usually gives off by the lungs, about twice as much carbonic acid as the latter.

"4. In man, the quantity of carbonic acid exhaled steadily increases from the age of eight up to that of thirty, and this continuous increase acquires a great and sudden impetus at the period of puberty. After thirty, the exhalation of carbonic acid begins to decrease, and this decrease becomes more and more marked, in proportion as the individual approaches the confines of extreme old age; and to such a degree, indeed, that at this period of life, the exhalation of carbonic acid by the lung may be similar to that met with at about the age of ten.

"5. In women, the exhalation of carbonic acid increases, according to the same laws by which this increase is regulated in man, during the second period of childhood. But, on the apparition of the catamenia at the period of puberty, this exhalation, contrary to what takes place in man, suddenly becomes stationary, or nearly so, as long as the menstrual periods occur with due regularity. At the close of menstruation, the exhalation of carbonic acid by the lungs suddenly increases in a remarkable degree; it then, as in man, gradually decreases in proportion as the female advances in years.

"6. During pregnancy, the exhalation of carbonic acid becomes, for the time being, as great as in females who have ceased to menstruate.

"7. In the two sexes, and at every age, the amount of carbonic acid exhaled by the lungs is greater in proportion to the strength of the constitution, and to the development of the muscular system."*

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* This last result is confirmed by certain cases, in which, after the persistence of a purely pathological debilitating cause, the exhalation of carbonic acid by the lungs became much diminished.

SECT. V.—Of Expectorated Matters.

These are of various kinds, and the investigations which we have recently undertaken relative to mucus and its modifications, will considerably facilitate our study of the various constituents of the expectoration.

These are as follows:

1. The saliva, which we have already examined; and, more especially, the mixed saliva.

2. Whitish flakes, derived from an undue secretion of the tonsils. An examination of these flakes shews them to be composed of morbid mucus, containing a certain quantity of fatty matter resembling tallow, and holding together the mucus, epithelium, and mucus globules.

3. Healthy mucus.
4. Morbid mucus.
5. Purulent mucus.

We have already carefully considered the characteristics of these three last varieties of mucus.

6. Blood.

We here exclude pure blood, the result of pulmonary or bronchial hæmorrhage, and confine our attention exclusively to blood molecularly combined with other matters, and constituting the basis of certain forms of expectoration; as, for instance, the rusty expectoration of pneumonia.

7. Pure pus.
8. Gangrenous matter.
9. Tubercular matter.
10. Melanotic matter.
11. False membranes.

The combination of these different matters gives rise to several varieties of expectoration, which we shall now proceed to consider.

1. *Expectoration composed of simple Mucus.*—This variety of expectoration is by no means frequent: it is met with at the commencement of acute bronchitis, and in some cases of emphysema unaccompanied by severe bronchitic complication.

In these cases of emphysema, the mucus is mixed up with air bubbles, and its chief characteristic is that of being frothy. We must admit, therefore, two varieties of simple mucous expectoration: the one containing but little air; the other, a large amount of the same. Usually, we find these forms of expectoration mingled with mixed saliva. For the chemico-physical characters of this variety of expectoration, we refer the reader to the subject of mucus in general, as treated of at page 401 of this work.

2. *Expectoration formed of Morbid Mucus.*—The composition of this variety of expectoration is that which has been already given in the table, page 407.

Its physical characters are as follows. The expectoration is more or less abundant, thick, viscid, and of average consistence. Its colour may vary, being white, yellowish, or greenish. These three tints correspond to a greater or less amount of pus globules. In proportion as these latter are abundant, does the colour of the expectoration assume a dark yellowish green tint.

3. *Expectoration formed of Purulent Mucus or Pure Pus.*—We find it necessary to class these two varieties under one head, inasmuch as it is rare to find pus, without a certain quantity of healthy or morbid mucus, or mucine.

This variety of expectoration is met with under the following circumstances:

1. In abscess of the lung (a rare disease, but one which may occur).—When an abscess opens into the bronchial tubes, the pus may be pure and contain scarcely a trace of mucus.

When a cavern or vomica exists, and the tubercular matter has been partially evacuated, the walls of the cavern become the seat of a more or less abundant purulent secretion. That variety of expectoration to which the term *nummular* has been applied, is merely another form of purulent expectoration. Its formation has been thus explained. A certain quantity of pus, in fact a globular mass of this substance, is expelled by a single effort from one of the anfractuosities of a cavity. This small portion of pus is homogeneous, having a tendency to be eliminated and expectorated *en masse*, without losing its homogeneity; in its passage outwards, it becomes surrounded with semi-transparent mucus, which gives it a globular envelope, and it is only on falling into the vessel destined for its reception, that it becomes flattened, and presents, in its centre, a mass of pus surrounded with a semi-transparent mucus.

This variety of expectoration does not necessarily indicate the presence of pus in the lungs. In certain forms of bronchitis, more especially when occurring after measles, we often meet with similar, or rather analogous expectoration, due to a globular formation of muco-pus in the pulmonary vesicles, which, during expulsion, becomes surrounded with transparent mucosity, and even with salivary mucus.

4. *Rusty Expectoration.*—This variety of expectoration, characteristic of the first stage of pneumonia, is composed of bronchial mucus, blood globules, serum, and a small quantity of fibrin. The microscope detects numerous epithelial cells, together with blood and mucus globules. The depth of colour depends on the number of blood globules. The viscidity which characterizes this variety of expectoration, is due to the presence of those constituents of the blood, and more especially of the fibrin, which undergo a species of semi-coagulation, of a gelatinous consistence, as sometimes occurs in the case of blisters, where the serum coagulates *en masse*.

There is a variety of rusty expectoration, more especially peculiar to the second stage of pneumonia (hepatization). It differs from the preceding, in its colour, which resembles apricot juice, and in being somewhat more viscid. In spite of the absence of the red tint, this variety must be included under the head of rusty expectoration, inasmuch as the microscope reveals the presence of numerous globules, while analysis shews it to contain all the constituents of the blood. Its viscidity may be explained upon the same principles as that of the rusty expectoration properly so called. In these two forms of expectoration, M. Gubler asserts that it is easy to detect small clots of blood; we have not, however, been able to verify his assertion.

5. *Prune-Juice Expectoration.*—This is, in general, thin, slightly viscid, and mingled with greyish streaks. Its comparison to prune juice is not strictly correct, the red colour of the former being less marked than that of the latter.

This variety of expectoration, however, which indicates the third stage of pneumonia (grey hepatization, or purulent infiltration), is far from being constant, and when it does actually exist, it is found to contain very little mucus, a small quantity of blood, and sero-purulent fluid, that is to say, an albuminous fluid, holding in solution a large number of pus globules.

The expectoration accompanying this stage of pneumonia, may be simply and entirely purulent.

6. *Gangrenous Expectoration.*—This is composed of purulent mucus, having a greyish colour and a less degree of viscidity than muco-pus properly so called. It has, moreover, a peculiar fœtid odour, which is characteristic.

Analysis shews its basis to be formed—1. Of muco-pus, derived from inflamed bronchial tubes; 2. Of a certain quantity of pus, as indicated by the presence of pus globules; 3. Of blood globules, with their organic amorphous detritus; and lastly, of fat globules, which are generally of large size. All these organic constituents may readily be recognized by means of the microscope.

7. *Tubercular Expectoration.*—This variety is nothing but muco-purulent or nummular expectoration, in which are found whitish flakes, of slight but cheesy consistence, usually considered as being fragments of tubercular matter. This question we shall discuss, when treating of the chemical analysis and the microscopic examination of tubercle. We may here state, however, that their tubercular origin is admitted, rather upon the evidence afforded by the stethoscopic signs and general symptoms of the disease, than upon that derived from chemical and microscopic examination.

8. *Pseudo-Membranous Expectoration.*—This variety is characterized by the presence of small fragments of whitish coloured false membranes, of slight consistence, and surrounded by more or less purulent mucus. The nature of the patho-

logical phenomena accompanying this form of expectoration is, alone, almost sufficient to cause its recognition.

9. *Expectoration of Carbonaceous Matter.*—We sometimes meet with expectoration of a grey, blue, or even black colour. The experiments of Christison, Graham, and Gregory, have shewn this to be a result of the mechanical decomposition of charcoal dust. It has been chiefly observed in individuals who were much exposed to the smoke of lamps, and to the dust of charcoal, etc. It is constantly met with in those who are employed in coal mines; and it is a remarkable fact, that, according to the experience of the physician to the mines of Auzin, the phenomenon in question is met with many years after a total cessation of labour in the interior of the galleries.

The expectoration which accompanies the softening of melanotic deposit in the lungs, may sometimes be mistaken for this carbonaceous matter.

SECT. VI.—Of the Gastric Secretions.

The mucous membrane of the stomach furnishes two secretions, entirely distinct the one from the other. The first is formed during fasting, when the stomach is empty and digestion accomplished. The second is the gastric juice, which is only secreted when food is introduced into the stomach.

1. OF THE SECRETION OF THE STOMACH WHEN EMPTY.

Gastric Mucus.—We must here at once state as a singular circumstance, that the surface itself of the gastric mucous membrane is acid; this fact, long admitted, has of late been confirmed by the experiments of M. Bernard. In spite, however, of this acidity of the free surface of the mucous membrane, the fluid secreted by the membrane itself is either neutral or alkaline.

This fluid is almost entirely composed of mucus.

This mucus is viscid, and stringy; its colour is greyish white. When examined under the microscope, it presents, according to Weber, flakes of from 0.0013 to 0.0020 of a line in diameter; these are capable of subdivision into still smaller granulations, of from 0.008 to 0.0012 of a line in diameter, according to Krauw. Epithelial cells are likewise met with.

This kind of mucus possesses the property of frothing when agitated. On being exposed to the air, it loses its watery portion, dries up, and leaves a brittle, somewhat brilliant, and transparent layer, not unlike gum. It mixes readily with water, which it absorbs, and which causes it to expand, without, however, dissolving it.

It is precipitated by acetate of lead, is insoluble in acetic acid, does not coagulate upon the application of heat and nitric acid, but does so on the addition of alcohol.

The gastric mucus may be increased in quantity under certain circumstances, without undergoing any change of composition. This increased amount of mucus has given free scope to the imagination of physicians, and for a considerable length of time, it was regarded as characteristic of that saburral condition of the stomach, to which the term "*embarras gastrique*" has more recently been applied.

This affection is marked by functional derangement of the stomach, and certain general phenomena which are sympathetic of this condition; nothing, however, proves its anatomo-pathological characteristic to be an increased secretion of the gastric mucus.

This increase, however, when it occurs, characterises the disease termed *gastrorrhœa,* in which the mucous membrane of the stomach secreting an undue quantity of mucus, there result watery eructations and a feeble digestion, probably due to the fact of the gastric juice being, at the moment of secretion, diluted by the unusual amount of mucus present in the stomach. Hence the languor of the digestive functions in general. We may add that, in these cases, there is, very frequently, an increased secretion of gas.

A knowledge of the real nature of this disease, readily explains the success which attends its treatment by emetics. These not only remove the abnormal quantity of mucus present, but likewise modify the condition of the mucous membrane itself.

2. SECRETIONS OF THE STOMACH DURING DIGESTION.

Gastric Juice.—The gastric juice is an intermittent secretion of the stomach, produced only when food is introduced into that viscus.

Thanks to the numerous researches of modern physiologists, the gastric juice is now perfectly understood. We shall, therefore, as succinctly as possible, state what is known respecting it.

The gastric juice is acid. This is most satisfactorily proved to be the case, in spite of the numerous controversies to which the question has given rise.

The nature of this acid has likewise been much discussed. Prout, Tiedemann, and Gmelin, have stated it to be the hydrochloric. The two latter authorities have also found acetic acid, but they attach less importance to it than to the former acid. Chevreul, Leuret, Lassaigne, and, more lately, MM. Bernard and Barreswill, have pronounced in favour of the lactic acid. M. Blondlot thought, that the acid nature of the gastric juice was due to the presence of biphosphate of lime.

In his *Lectures on Physiology,* M. Berard, after discussing with great lucidity the nature of the acid existing in the gastric juice, concludes, by the process of exclusion, that it is the lactic acid.

The gastric juice contains certain other chemical constituents.

Tiedemann and Gmelin have pointed out the following:

Carbonate of lime;
Phosphate of lime;
Chloride of sodium and calcium;
Hydrochlorate of ammonia;
Acetate of soda;
Osmazome;
Salivary matter;
A small quantity of albumen, and some other undetermined organic substances.

According to MM. Leuret and Lassaigne, the gastric juice contains, in addition to lactic acid, ninety-eight parts per hundred of water;

Hydrochlorate of ammonia;

Chloride of sodium;

Phosphate of lime;

Mucus, and an animal substance soluble in water.

M. Blondlot has given the following table as the result of his analysis:

Water		99
Organic matter	Acid phosphate of lime Phosphate of ammonia Chloride of calcium An aromatic principle Mucus A peculiar substance	1
	Total	100

To this may be added another special organic matter, to which the term *pepsine*, or *gasterase*, has been applied. This substance we shall now consider.

According to MM. Robin and Verdeil, pepsine is but little soluble in water; it bears a considerable resemblance to albumen, coagulates at 100° (centigrade), and does not produce an insoluble compound with ferro-cyanide of potassium. It is precipitated by anhydrous alcohol and is soluble in a large amount of water, more especially if acidulated. Ebullition causes its solution to lose the power of dissolving white of egg, which it previously possessed.

Sulphates, acetates, and metallic chlorides precipitate pepsine. It is readily separated from acetates by means of hydrochloric acid, and then remains in combination with a small quantity of acid, forming *acetate of pepsine*, which, when dissolved in six thousand times its weight of water, still possesses the property of dissolving boiled white of egg.

According to M. Bernard, articles of diet are not dissolved in the stomach. They merely undergo expansion by their admixture with the gastric juice; and it is only lower down, in the small intestine, that, under the influence of the bile, nitrogenized matters, muscular fibre, etc., etc., are really liquified.

It would appear certain, from the last researches of M. Bernard, that the gastric juice does not cause the solution of articles introduced into the stomach, but that the acid which it contains merely expands and softens them. It is, perhaps, therefore, the special organic matter, or the stomachal mucus peculiar to the gastric juice, which effects this solution in the small intestines.

As for the substance termed *pepsin* by some authors, it is not, according to MM. Robin and Verdeil, a separate substance or immediate principle; but merely a product resulting from some modification of the nitrogenized matters of the gastric parietes. It has, moreover, been ascertained by Burdach, that a similar expansion of nitrogenized matters can be produced by means of fragments of trachea, lung, liver, cellular tissue, etc., but that liquifaction cannot thus be obtained.

This supposed pepsin has been described by Schwann, who first gave directions for its preparation. Vogel has done so likewise. M. Payen has given it the name of *gasterase;* and M. Deschamps (d'Avallon), that of *chimosine.*

The existence, however, of this substance being still denied, we do not think it necessary to state the processes that have been adopted for its preparation.

From the foregoing description of the gastric juice, it is easy to see, that in spite of the many curious experiments recently made, relative to digestion, we are, comparatively speaking, but little advanced respecting the chemical history of this fluid.

If, however, science has made so little progress as regards the normal composition of the gastric juice, we must of necessity know still less of the pathological changes to which it is liable. We may safely say, therefore, that of the morbid conditions of the gastric juice we are entirely ignorant.

Can the gastric juice, we might ask, undergo a morbid increase in point of quantity, and thus form the constituent portion of a vomit? Such an opinion is held by many, and yet nothing can be more erroneous. Except during digestion, the gastric juice is not secreted by the mucous membrane of the stomach, and it cannot, therefore, accumulate in that organ and be rejected by vomiting. There is but one circumstance under which the gastric juice can be found in vomited matters, viz., when these last are the consequence of indigestion, and when the act of vomiting takes place during the digestive process. In such a case, we observe undigested and half-digested food mingled with the gastric juice. Except under such circumstances, the gastric juice cannot be ejected from the stomach by the effort of vomiting.

We occasionally, however, meet with cases in which there occurs a regurgitation of acid fluid; and even vomiting of a similar fluid may take place when the stomach is empty. The fluid in these cases is not the gastric juice, but the product of imperfect digestion, which has given rise to a species of acid fermentation.

SECT. VII.—Of Vomited Matters and Vomiting.

Before considering the various kinds of vomiting, we shall pass in review the different organic matters of which they may be composed. We shall then endeavour to ascertain how these substances may combine, so as to constitute the varieties in question.

The following substances may be met with in the matter ejected from the stomach by the act of vomiting:

1. *Undigested or half-digested aliment,* as occurs in indigestion, in certain cases of intestinal obstruction, in cancer of the pylorus.
2. *Fluids,* if vomiting take place shortly after they have been swallowed; for their absorption takes place with great rapidity.
3. *Gastric mucus,* presenting the characteristics which we have lately pointed out.
4. *Gastric juice* (lactic acid and pepsin), when the act of vomiting occurs during the process of digestion.

5. *Albumen*, as occurs in certain cases of cholera.

6. *Chloride of sodium*, which is met with in almost every species of vomit, but especially in that of cholera.

7. *Blood.*—When in large quantities, it is thrown up in a state of purity. It is generally, however, black and grumous, and may readily be detected by the naked eye.

When the blood is derived from the parietes of the stomach, and is secreted, as it were, molecule by molecule,—when, moreover, the quantity is small, or has remained for some length of time in the stomach, it undergoes certain special modifications, which have of late been accurately investigated. The fluid containing the blood becomes first brown, then blackish brown, and lastly blackish, resembling a mixture of soot and water. There can be now no doubt, but that this species of vomiting is due to a peculiar modification of the blood. What, then, is this modification?

When blood exists in the stomach, it ere long begins to undergo the process of digestion; and gastric juice being necessarily secreted, the following changes take place:

The insoluble matters of the blood are partially dissolved, and the hæmatin of the globules, under the influence of the acid, assumes a brownish black colour. On examining this dark fluid under the microscope, we perceive numerous organic amorphous particles, together with blood globules, which are rarely perfect, but irregular and serrated.

Chemical analysis shews this liquid to be albuminous, being coagulable by heat and nitric acid. Its reaction varies, being either neutral, acid, or alkaline, according to the time at which it is examined, and to the stage of digestion.

The sources from whence this blood may be derived are various. Sometimes it exudes from the healthy mucus membrane. This variety of idiopathic hæmorrhage is very rare, its existence even has been denied by many physicians, nor, indeed, is the question as yet decided. At other times it is the result of acute or chronic gastritis; of a simple chronic ulcer of the stomach; of cancer, whether at an early stage, in virtue of chronic irritation of the non-ulcerated mucous membrane; or, at a later period, when the cancerous mass has ulcerated. Blood, again, may find its way into the stomach, from the opening of an aneurism into its cavity; or it may be the result of some mechanical obstacle to the circulation, as in organic diseases of the heart, cirrhosis of the liver, in certain constitutional affections, characterized, either by a decrease of the fibrin of the blood, or by an increase of the soda which it contains: thus, for instance, in certain typhoid fevers, small-pox, yellow fever, acute and chronic scurvy.

Various other causes might here be adduced; we merely, however, mention the principal ones.

8. *Bile*, or some of its elements, is often found in vomited matters. For this to happen, the bile must, necessarily, in virtue of the antiperistaltic movement of the duodenum, regurgitate into the stomach, through the pylorus. This phenomenon, however singular it may appear, is, nevertheless, by no means uncommon. In every variety of vomiting, a small quantity of bile may be met with; but there are some circumstances which more especially give rise to bilious vomiting. These are: jaundice, a general bilious condition of the system, bilious fevers, peritonitis, acute and chronic hepatitis, biliary calculi; *i.e.*, cases in which there is an impediment to the flow of bile; increased secretion of that liquid (biliary flux), and irritation of the liver from inflammation of its substance, or of the serous membrane with which it is in contact.

9. *Albuminous Serosity.*—This may occur as a consequence of encysted tumours or hydatid cysts, opening accidentally into the stomach.

10. *Pus.*—Pus is sometimes met with in vomited matters. Its existence may be detected by the presence of the characteristic pus globules, while the physical qualities of the fluid itself are alone sufficient to excite a suspicion of its existence. The sources from whence the pus is derived in these somewhat rare cases, are the following: toxic inflammation of the mucous membrane of the stomach, with ulceration of this membrane. The pus, moreover, may be derived from an open cancer, or from an abscess opening into the stomach: it is thus that we

meet with cases in which abscess of the liver or of the kidneys, circumscribed peritonitis, and purulent pleuritic effusions, have given rise to the vomiting of purulent matters. The pus, again, may be derived from a very different source, in other words, it may be swallowed. Thus, it may proceed from the mouth, the pharynx, the larynx, or the bronchi. In children, the expectorated matters, which are usually swallowed, may, in this way, be found in those which are ejected from the stomach.

11. *Cancerous Exudation.*—The characteristics of this substance are not sufficiently well defined to enable us to state, *à priori*, that it exists in vomited matter. Nevertheless, the presence of the cancer-cells (by those who adopt this view) may possibly be detected under the microscope.

These different substances may give rise to several kinds of vomiting, which have, for the most part, received distinctive appellations.

a. Mucous Vomiting.—The matter ejected in this case, is almost entirely composed of mucus, which sometimes presents a yellow tinge, from being mixed with a small quantity of bile.

This kind of vomiting is very frequent. The majority of cases of nervous vomiting are of this description; as also those produced by passion, emotion, disgust, etc.

b. Vomiting of Alimentary Matters.—This occurs when the vomiting, whatever be its cause, takes place during the process of digestion. There are, however, many cases of vomiting occurring during this act, in which the matter ejected is simply mucus. This may take place in gastralgia, and likewise in cancer.

c. Bilious Vomiting.—This is often composed of pure bile, mingled with a certain amount of mucus.

d. Vomiting of Blood.—When of recent occurrence, the character of the vomited matters is sufficient to enable us to recognize the presence of this fluid.

e. Black Vomiting.—This is caused by the presence of blood in an altered and partially digested state. We have already explained the nature and causes of this alteration.

f. Albuminous Vomiting.—This occurs in cholera; we shall speak of it presently.

g. Purulent Vomiting is that in which the ejected matters contain such an amount of pus, as to render its nature at once apparent. That species of purulent vomiting which is due to the presence of expectorated matters previously swallowed, must be ranged under another head.

We may now pass on to an analysis of the matters ejected by vomiting in certain diseases.

1. OF THE CHOLERA VOMIT.

In the year 1849, we analyzed the matters vomited by several individuals attacked with cholera. The following table shews the composition of these matters.

	Reaction.	Density.	Water.	Solid matters in 1000 grammes of filtered fluid.	Albumen in ditto ditto.	Chloride of sodium.	Matters in suspension or remaining in the filter.
A woman, 30 years of age; vomiting 50 hours after the commencement of the attack . . .	Neutral.	Not ascertained	991.52	6.37	Impond.	2.35	2.11
A man, 23 years of age; cholera supervening while in hospital, lasting only 8 hours; vomiting during the middle of the attack . .	Acid.	1006.03	991.02	7.04	Impond.	3.08	1.01
A man, 50 years of age; cholera lasting 12 hours; commencement of reaction	Neutral.	1012.20	967.18	26.31	5.11	4.00	6.21
A woman, 42 years of age; cholera of 4 days date; the vomiting, of only 48 hours date . . .	Acid.	1015.53	960.20	31.63	18.40	4.24	7.47
A woman, 45 years of age; vomited matter collected, 4 hours before death	Acid.	1017.20	954.4	36.08	7.24	5.25	8.90
A woman, 28 years of age; cholera of 8 hours date	Acid.	1021.40	931.46	54.70	31.50	6.75	11.24

This table contains an analysis of the vomited matters collected from six different individuals, all in a very dangerous condition.

In each case, the ejected matters presented the marked characteristics of the cholera vomit, a whitish colour, and rice-water appearance.

Each specimen when filtered, left behind it an insoluble residuum and a perfectly transparent fluid. These were examined with the greatest care. The first, or insoluble portion, was found to be composed of coagulated albumen, the fragments of which were united by a very small and almost imponderable quantity of mucus. The albuminous nature of these insoluble fragments appears to be positively demonstrated by chemical and microscopic analysis. This substance, when repeatedly washed with distilled water and alcohol, and then dried, was weighed; the results thus afforded may be found in the columns of the preceding table, and are somewhat remarkable. The quantity of this insoluble substance was found to be in proportion to the aggregate of the matters held in solution by the filtered fluid.

Another result, less positive it is true, but equally applicable to the matters held in solution, is this: viz., that the quantity of each decreases in proportion as the disease progresses. In 1000 parts of liquid, the coagulated albumen varied from 1.94 grammes to 11.24 grammes.

Examination of the Filtered Fluid.—The filtered fluid was perfectly limpid and transparent; in two cases it was neutral, and in two, acid.

This fluid, when dried, afforded very different results. The aggregate amount varied from 6.37 grammes to 54.70 grammes, and was, as we have before stated, proportionate to the weight of the insoluble portion, and, likewise, to the density of the liquid itself, as carefully ascertained after filtration.

We have succeeded in isolating some of the immediate principles of which the dried mass, just alluded to, is composed, more especially the chloride of sodium and albumen; with the following results. In each case, the fluid contained albumen, coagulable by heat; in two of these, the quantity was so small as to be imponderable; in four others, it varied from 5.10 grammes to 3.50 grammes: in the latter, only, was the albumen partly constituted by the principle to which the name *albuminose* has been given; this principle is incoagulable by heat, but coagulates on the addition of rectified spirit. The proportion of albumen was greatest, where the vomiting occurred at the early stage of the disease. Compared with the aggregate of the matters held in solution, when dried and placed in juxta-position with the results already obtained, relative to the serum of the blood, we find the quantity of albumen in question, to be proportionably much smaller.

A large proportion of chloride of sodium is found in the vomited matters of cholera patients; the quantity varies from 2.35 grammes to 8.24 grammes; a considerable amount when compared with the aggregate weight of the matters held in solution. On comparing, on the other hand, this result, with the proportion of chloride of sodium naturally existing in the blood, we find, that the amount of this salt existing in the vomited matters of cholera patients, is three times as great as in the former fluid. Such a comparison is the more needful, inasmuch as the quantity of water contained in the matters ejected by the stomach and bowels varies considerably, and is proportionate to the amount of fluids given to the patients;* while, on the other hand, the aggregate of the solid matters held in suspension or solution, is the only important element of investigation.

This large proportion of chloride of sodium, is one of the most important results of our analyses.

To sum up, then; the analysis of the matters vomited in six cases of cholera, enables us to regard this morbid fluid as constituted by the serum of the blood, diluted with, in general, a large amount of water containing coagulated albumen, and holding in solution, moreover, a large proportion, relatively speaking, of chloride of sodium.

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* It may be proper here to state, that the patients in question drank nothing but iced Seltzer water.

2. OF THE VOMITING IN PERITONITIS.

An analysis of the matters ejected from the stomach in peritonitis was, made by Simon, thus:

Water	971.0
Solid matters	29.0
Fat	4.0
Bilifellinic acid,* alcoholic extract, and biliary pigment	1.5
Alcoholic extract, with a little bilifellinic acid	11.4
Albuminate of soda	5.4
Mucus and albumen	5.8

Heller† has analyzed the leek-green vomiting of peritonitis, occurring in a young female, twenty years of age. The fluid was acid, and yet neither hydrochloric nor acetic acid were present. Its specific gravity was 1006, and it contained no albumen. Its composition per 1000 was as follows:

Water	990.50
Solid matters	9.50
Fat	0.24
Watery extract	1.30
Biliverdin, with a little bilifulvin and a trace of alcoholic extract	5.38
Fixed salts	3.75

The fixed salts were the chlorides of sodium and of calcium, in combination with a small quantity of phosphate of soda, sulphate of potash and earthy phosphates.

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* Berzelius describes, under the name of bilifellinic acid, a compound of bilin (choleate and cholate of soda) and fellinic acid. This latter being an artificial product, resulting from the action of hydrochloric acid upon bile, and occurring previous to the formation of dyslysine.

† *Archiv.*, vol. i, p. 226.

SECT. VIII.—Of the Intestinal Secretions.

Under this head we shall consider in succession:

1. The *Intestinal Mucus.*
2. The *Alvine Evacuations, or fæcal matters.*
3. The *Intestinal Concretions.*
4. The *Intestinal Gases.*

1. INTESTINAL MUCUS.

The mucus secreted by the intestinal glands, does not differ much from that secreted by the mucous membrane of the stomach; it is only somewhat more abundant; the quantity, however, varying according to circumstances. In certain cases, it may accumulate within the intestines.

The intestinal mucus, while in general neutral, is sometimes slightly alkaline. According to Schultz, it is acid in the small intestine, and alkaline in the rectum. It is almost exclusively composed of the substance denominated *mucosine* or *mucine.* It is of a greyish white colour, semi-transparent, viscid, like that derived from the stomach, and contains, according to Weber, flakes of from 0.0013 to 0.0020 of a line in diameter, capable of still further subdivision into small granulations of from 0.008 to 0.0012 of a line in diameter, according to Krauw.

The effect of reagents upon the intestinal mucus, is similar to that produced upon the gastric mucus. After being repeatedly washed in distilled water and dried, it loses its property of becoming mucous on the addition of water, unless a small proportion of alkali be added to this latter.

2. FÆCAL MATTERS (EXCREMENTS).

The fæcal matters, or fæces, are the residuum of digestion. They constitute a semi-solid, pulpy mass, varying in colour according to the nature of the food. This mass is sometimes homogeneous, at other times its consistence is variable. It is composed of the residue of digested aliment, of fragments of undigested matter, of mucus, and of biliary and pancreatic residuum.

The nature of the excrements varies according to age, sex, constitution, temperament, diet, and climate. The question is one, of which we cannot here treat, nor, indeed, would it be of much interest.

The amount of excrementitious matter passed in the twenty-four hours, is about 200 grammes ($6\frac{1}{4}$ oz.). It forms about 0.06 to 0.10 of the ingested matters. According to various experimenters, the quantity, when calculated by ounces, is, relatively to the solid and fluid aliment taken, from 8 : 91=1 : 11 (Gorter); from 6 to 7 : 80=1 : 11 to 13 (Hartmann); from $5\frac{1}{2}$: 86=1 : 15 in early life, and from $3\frac{1}{2}$: 58=1 : 16 in advanced age; from $3\frac{1}{2}$: 67=1 : 18 (Home); lastly, from 5 : 91=1 : 18 in winter, and from $4\frac{1}{2}$: 90=1 : 20 in summer (Dalton). The proportion, in relation to aliment, is about 1 : 7 or 1 to 8; so that 0.85 or 0.87 of this latter passes into the blood.

The fæcal matters are acid, according to Vauquelin; alkaline, according to Schultz and Berzelius.

No other quantitative analysis of the fæces has been made since that of Berzelius, in 1804. We shall not here describe the long and complicated process which he adopted, but merely give the results obtained.

Water	733.0
Solid matters	267.0
Bile	9.0
Albumen	9.0
A peculiar extractive matter	27.0
Salts	12.0
Residue of insoluble aliment	70.0
A peculiar animal matter	140.0

The salts were as follows:

Carbonate (lactate of soda)	3.5
Chloride of sodium	4.0
Sulphate of soda	2.0
Phosphate of magnesia	2.0
Phosphate of lime	4.0

Numerous experiments have been made by Enkerlin upon the salts contained in human excrements. The following is an analysis of fæces, of fleshy appearance and alkaline reaction.

Products of incineration:

Tribasic phosphate of soda (a small quantity);
Chloride of sodium;
Alkaline sulphates;
Phosphates of lime and magnesia (in abundance);
Carbonate and sulphate of lime;
Phosphate of iron (a trace).

Produce of the aqueous extract of the same fæces, when dried and incinerated:

Alkaline carbonates;
Alkaline phosphates;
Alkaline sulphates;
Chloride of sodium and earthy phosphates.

Remains of the aqueous extract, from which an alcoholic extract, dried and incinerated, had been removed by means of alcohol:

Phosphate of lime and magnesia;
Sulphate of lime;
Traces of chloride of sodium and of alkaline phosphates.

The following is the analysis of another specimen of fæcal matter, likewise made by Enderlin:

Chloride of sodium and alkaline sulphates	1.367	soluble in water.
Bibasic phosphate of soda	2.633	
Phosphate of lime and magnesia . . .	80.372	insoluble in water.
Phosphate of iron	2.090	
Sulphate of lime	4.530	
Silica	7.940	
	98.932	

100 parts of the solid residue of the fæces of this same individual were thus constituted:

A substance soluble in æther (yellowish brown fatty matter)	11.95
Ditto ditto in concentrated alcohol	10.74
Ditto ditto in water (brownish resinoid matter) .	11.61
Organic matter insoluble in the above fluids	49.33
Salts soluble in water	4.76
Salts insoluble in water	11.61

A. MECONIUM.

The meconium consists of a thick, glutinous, greyish black mass, having the insipid odour of perspiration. When examined under the microscope, we perceive a number of epithelial cells, together with crystallized rhomboidal plates of cholesterine. A greyish coloured, amorphous mass is likewise seen; this has been stated, by Simon, to be formed of altered blood corpuscles.

The aforesaid chemist gives the following analysis of the meconium.

100 parts of meconium when dried afforded:

Cholesterine	16.0
Extractive matter and bilifellinic acid	14.0
Casein	34.0
Bilifellinic acid and bilin	6.0
Biliverdin and bilifellinic acid	4.0
Cells, mucus, albumen	26.0

Dr. Davy has likewise analyzed various specimens of meconium derived from healthy and still-born children. They were all composed of numerous epithelial cells, mucous globules, and blood corpuscles.

The following is an analysis of the meconium of a healthy child immediately after birth:

Water	72.7
Mucus and epithelial scales	23.6
Cholesterine and margarine	0.7
Biliary matter and olein	3.0

B. OF DIARRHŒA.

Diarrhœa is a symptom which consists in the passage of stools, composed either of softened and liquid fæcal matters, or of newly formed products, equally fluid. We shall here then, as when treating of matters ejected by vomiting, examine, in succession, the various substances of which the alvine evacuations may be composed. These we shall then consider in the aggregate, and thus endeavour to ascertain the species or varieties which may be admitted to exist.

1. *Softened Fœcal Matter.*—This is very frequently met with: it occurs in the great majority of cases of diarrhœa.

2. *Semi-digested Aliment.*—This is, likewise, by no means unfrequent. In that form of diarrhœa denominated *lientery*, we almost always find a certain quantity of undigested food.

3. *Mucus.*—In diarrhœa generally, the proportion of mucus is increased; but, independently of this, there are cases in which mucus, either alone or combined with some other morbid material, constitutes the entire evacuation.

In cases of obstinate constipation, we often find, that hardened fæces, or scybalæ, are evacuated along with a greater or less quantity of pure mucus.

In inflammation of the colon, the evacuations may be composed of almost pure mucus. This does not happen in inflammation of the small intestines: in the latter affection they almost always contain true fæcal matter, with which they have become incorporated, during their passage through the cœcum, colon, and rectum.

In dysentery, the evacuations are sometimes composed of bloody mucus, at other times of pure mucus. The presence of blood, whether mixed with mucus or in a state of purity, does not necessarily indicate ulceration of the colon. Simple acute inflammation of the mucous membrane of this intestine may give rise to the symptom in question.

4. *Blood.*—Blood is often found mingled with the fæcal matters, and in such cases it may arise from very different causes, and be derived from very different sources. In the first place, it may be a symptom of hæmorrhoids. This is by no means uncommon, the blood being then of a very dark, blackish colour, almost always fluid and in a state of purity. If it escape along with the fæces, it is not mixed up with them, but surrounds and lubricates the mass; at other times it constitutes the entire evacuation, being unaccompanied by fæcal matter. In inflammation of the colon without ulceration, the blood is usually met with in small quantities, and almost

always mingled with a certain amount of mucus, to which it imparts a greater or less degree of colour.

When ulceration exists, the amount of blood evacuated may vary considerably. In some cases, it is scanty, and appears in the form of filaments. In others, the quantity thus lost may be very great, owing to the destruction of some large vessel, by the ulcerative process going on within the intestine.

In cancer of the rectum, and, what is still more uncommon, in that of the colon, the blood is blackish, grumous, and usually mixed with a small quantity of fæcal matter.

In diseases of the small intestines, the blood is always more intimately mixed up with the fæcal matters, than in affections of the large intestines.

Here, again, the sources from which the blood is derived are various; and first it may be stated, that unless the quantity be very large, it forms, with the mucus and fæcal matters, which it helps to soften, a mixture, or rather a pulp, of variable consistence, and of a chesnut or reddish brown colour. This, alone, is generally sufficient to reveal the presence of blood. In doubtful cases, however, the microscope serves to elucidate the question.

Blood may be derived from the small intestines under the following circumstances:

a. As the result of idiopathic hæmorrhage; this, however, is very rare.

b. At the commencement of typhoid fevers, and before ulceration has occurred, hæmorrhage may occasionally take place from similar causes to those which produce epistaxis.

c. It is at a later period, when ulceration has set in, that hæmorrhage most frequently occurs.

d. In the tubercular ulceration of phthisical individuals, intestinal hæmorrhage is sometimes met with, but not so often as in those affected with typhoid fever.

e. In cases where, as the result of some poisonous agent, the intestine has undergone a morbid change, ulceration, and consequently hæmorrhage, may occur.

f. In the scorbutic state, when the fibrin of the blood is deficient, and the proportion of soda is increased, intestinal hæmorrhage may sometimes take place.

g. Lastly, intestinal hæmorrhage may have for its source, the rupture of an aneurismal tumour.

The blood may, likewise, be derived from the stomach. In such cases it presents certain special characteristics, being partially digested, and of a sooty black colour. Whenever bloody stools present this blackish appearance, we may rest assured that the blood is derived from the stomach, inasmuch as it never undergoes such a change in the intestines.

5. *Bile.*—Bile is frequently met with in the fæcal matter of diarrhœa. At one time it is mixed up with the true fæces, at another it is passed almost in a state of purity. This occurs in bilious fluxes, whatever be their cause. It is often seen, moreover, after the administration of purgatives.

6. *Albuminous Serosity.*—This is sometimes pure, at others it is mixed up with certain excrementitious matters, or with a small quantity of bile.

The alvine evacuations of cholera and cholerine contain more or less of this fluid. It is occasionally met with in simple diarrhœa, as also after the administration of purgatives. It is generally admitted to occur, as a critical phenomenon, in cases of dropsy affecting other organs.

7. *Pus.*—Pus is not unfrequently met with in the alvine evacuations. It is usually the result of ulceration, whether simple, typhoid, tubercular, or cancerous, etc., etc. The quantity varies, being sometimes small, and presenting the appearance of greyish streaks; at other times abundant, and mixed with fæcal matter, so as to form a pulp of a brownish grey colour.

Occasionally the pus is derived from an abscess or purulent effusion, situated in some neighbouring organ and opening into the intestine. Purulent collections in the peritoneum and pleura, abscesses of the broad ligaments of the uterus, of the iliac fossæ, of the liver, kidneys, and spleen, etc., may open into the intestines, and be evacuated, either in the form of pure pus, or mixed with a greater or less amount of fæcal matter.

C. OF THE DIFFERENT FORMS OF DIARRHŒA.

These are as follows:

1. *Simple Diarrhœa.*—This is due to simple softening of more or less highly coloured fæcal matters.
2. *Diarrhœa, accompanied by the passage of undigested food.*—This is often termed *lientery.*
3. *Mucous Diarrhœa.*—This is characterized by a great increase in the quantity of mucus.
4. *Sanguineous Diarrhœa.*—In this variety, the fæcal matters are mixed with blood.
5. *Muco-sanguineous Diarrhœa.*—Here the evacuations are composed of mucus and blood, as in dysentery.
6. *A Discharge of Pure Blood.*
7. *Serous Diarrhœa.*—A discharge of serum or serosity, containing albumen in various proportions, and mixed up with certain foreign matters.

The diagnosis of these different kinds of diarrhœa cannot be accurately made, unless examined with great care. The employment of the microscope, and of certain chemical reagents, is especially necessary, when we wish to ascertain the nature of the substances which constitute the symptomatic phenomenon in question.

We shall conclude this subject by quoting a few analyses that have been made, relative to the nature of the evacuations met with in certain forms of diarrhœa.

C. DIARRHŒA OF CHOLERA.

In the year 1849, while engaged in analyzing the vomited matters of cholera patients, we likewise turned our attention to the subject of the alvine evacuations. The following table shews the results of our analyses in detail.

	Reaction.	Specific gravity.	Water.	Solid matters in 1000 grammes of filtered fluid.	Albumen in ditto ditto.	Chloride of sodium.	Suspended matters remaining on the filter.
A woman, 30 years of age; cholera of 50 hours date	Alkal.	1004.20	988.60	8.64	Impond.	3.7	2.76
A man, 44 years of age; stage of collapse . .	Do.	1007.40	979.57	13.29	Do.	„	7.14 bef. chol.
A man, 35 years of age; cholera of 18 hours date	Do.	1009.70	781.57	14.54	3.22	5.24	3.59
A woman, 29 years of age; cholera of 18 hours date	Do.	1011.01	982.83	15.12	4.51	7.81	2.05

The above analyses afford very similar results.

In each the reaction was alkaline; the alvine excretions could readily be filtered, and left on the paper an insoluble substance, absolutely identical with that found in the matters ejected from the stomach; in other words, coagulated albumen, of which the fragments were held together by a very small quantity of mucus. The proportion of this insoluble matter varied from 2.05 grs.* to 7.14 grs. in 1000 parts of fluid. The quantity of water was considerable. The aggregate of solid matters held in solution by the filtered liquid was, in general, small; it oscillated between 8.64 grs. and 15.12 grs. The specific gravity of the fluid being proportionate to the same.

Albumen, when carefully sought for, was found in each of these cases. In two, the quantity was so small as to be imponderable; in two others, it amounted respectively to 3.22 grs., 4.21 grs.

Chloride of sodium was found in considerable quantity, and under the same conditions as when met with in the matters ejected from the stomach.

To sum up then, we may state, that the conclusions at which we have arrived, respecting the alvine evacuations of cholera, are similar to those already adopted with regard to the vomiting in this disease, with the exception of the alkalinity of the former, due to a very small proportion of ammoniacal salts. The alvine evacuation of cholera is, in fact, nothing more than water containing a small quantity of albumen and a large amount of chloride of sodium, while fragments of coagulated albumen may be seen floating about in it.

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* Grs., *i.e.*, grammes.

We shall not attempt to deduce any hypothetical theories from these results, but content ourselves with offering a few remarks, in reference to the foregoing table.

May we not, in fact, admit, that under the influence of the cholera poison, a certain quantity of the solid matters of the serum of the blood, and especially of the albumen, are exhaled, as it were, by the mucous membrane.

In this exhalation, as occurs moreover in the majority of pathological exudations, the respective proportions of the solid matters and of the water are not preserved—the latter preponderates. If to this, we add the water introduced into the system during the disease, as a means of checking thirst, we may readily explain the enormous, albeit variable, amount of liquid met with in the evacuations of cholera patients.

The presence of coagulated albumen is probably the result of decreased alkalinity in some of the evacuations, and of a neutral or acid reaction in others.

As for the preponderance of chloride of sodium, we are unable to offer any reasonable explanation of the same.

The modifications occurring in the blood of cholera patients may, we conceive, be explained by reference to the above results. The water diminishes in this fluid, by reason of its increase in the intestinal secretions.

The result of this decrease of the watery part of the blood is a relative concentration of the globules, chloride of sodium, extractive matters and salts.

The marked decrease of the albumen of the serum is explained by its appearance in the intestinal secretions. As for the increase of the fatty matters, the proportion of which is almost tripled, may it not be attributed to the rapid absorption of adipose tissue which takes place in cholera?

Such are a few of the reflections suggested by our analyses.

Simon has given the following analysis of the fæcal matters of a cholera patient.

Water	980.00
Solid matters	20.00
Fat	0.08
Extractive matter	4.80
Albumen and mucus	0.52
Chloride of sodium, lactate and acetate of soda, and alkaline phosphates	13.40
Phosphate of lime and magnesia	0.60

Landerer has analyzed the evacuations of an infant affected with diarrhœa. The matters of which they were composed were yellow, bitter, of an acid reaction, and of specific gravity 1038.2.

Carbonate of lime	1.50
Phosphate of lime	2.00
Chloride of calcium	1.50
Chloride of magnesium	2.45
Chloride of sodium	2.43
Sulphate of lime	1.50
Sulphate of magnesia	0.80
Bilin, butyric acid, and extractive matter	3.00
Alcoholic extract	1.00
Free lactic acid and hydrochloric acid	1.00

ALVINE EVACUATIONS PRODUCED BY CALOMEL.

These are, for the most part, of a green colour; they have an acid reaction, and are inodorous. When examined under the microscope, they are seen to contain a large number of mucous globules and epithelial cells. Crystals of cholesterine, covered with biliverdin, may likewise be detected.

The following analysis of these evacuations has been given by Simon. 100 parts contained:

Green fat, containing cholesterine	10.0
Salivary matter, soluble in water and slightly precipitable by tannic acid and acetate of lead	24.3
Bilin, bilifellinic acid, and biliverdin	21.4
Extractive matter, soluble in alcohol	11.0
Albumen, mucus, and epithelial scales	17.1
Salts	12.9

No trace of mercury was found in the evacuations.

Analysis of the Green Evacuations of Infants. (Golding Bird.)

Water	900.00
Biliverdin, alcoholic extract, fat, cholesterine	24.50
Ptyaline, watery extract, coloured with biliverdin	11.25
Mucus, coagulated albumen, and hæmatin	56.00
Chloride of sodium, with traces of tribasic phosphate of soda	5.50
Tribasic phosphate of soda	1.75
Peroxide of iron	1.00
Total	1000.00

3. INTESTINAL CONCRETIONS.

The formation of concretions in the human intestinal canal is somewhat rare. They have occasionally been ejected, both by the mouth and anus, and after death they have been found throughout the whole extent of the intestinal tube.

Vogel admits two species of intestinal concretions. The first are formed in the canal itself; the second are developed in the neighbouring organs, and from thence escape into the intestines: such, for instance, as biliary calculi, which, in their turn, may serve as nuclei for true intestinal concretions.

The first alone constitute intestinal concretions properly so called, and are not always formed in the same manner.

1. Some derive their origin from a fibrinous exudation, or sanguineous clot, occurring accidentally in the digestive canal. The following is what then takes place: the soluble matters are dissolved and gradually washed away, whilst the insoluble portions, and especially the calcareous salts, remain mixed up with a certain amount of coagulated fibrin and alimentary *débris*. These concretions may be the result of inflammation or hæmorrhage of the intestinal tube.

The two following analyses, made by Davy, would appear to refer to concretions of this kind.

	1.	2.
Fibrin	78	74
Salts	21	7
Colouring matter, resin and fæcal matter	5	19

A foreign body may also serve as a nucleus for such concretions. As, for example, the kernel of certain fruits.

2. Intestinal concretions may be formed in a totally different manner.

These contain salts, and especially phosphate and carbonate of lime, and carbonate of magnesia. These salts are mixed up with fragments of alimentary matter, and thus form concretions, which sometimes have for their nuclei, foreign bodies.

Of their mode of formation we are still ignorant; it is probable, however, that, from some cause or other, the earthy salts are first rendered insoluble and then precipitated.

These concretions are generally expelled along with the alvine evacuations. We know, moreover, that, in many cases of diarrhœa, the fæces contain ammoniaco-magnesian phosphate, and phosphate of lime.

Thompson and Davy have analyzed concretions of this description, with the following results:

	1.	2.
Phosphate of lime	46	56
Triple phosphate	5	
Animal matter (fibrin)	25	42
Vegetable matter, resin, etc.	24	"

Children has also analyzed the crust of a concretion formed around the kernel of a plum. Its composition was as follows:

Animal matter, soluble in water, and soluble calcareous salts	25
Phosphate of lime	46
Ammoniaco-magnesian phosphate	5
Woody fibre	20
Resin (altered bile)	4
Total	100

3. Concretions are sometimes formed of fragments of ingested aliment grouped around some foreign body, which serves

as a nucleus. They are more especially composed of substances absolutely indigestible and insoluble, such as hair, epidermis, ligneous fibre, the husks and rind of fruit, etc. When these matters become agglomerated by means of the intestinal mucus, they may form concretions, which are sometimes as hard as wood.

In this case, as in the preceding, a peculiar condition of the intestinal canal is often necessary for their production: such as atony of the digestive organs, a stricture, an obstacle of any kind, constipation.

4. A certain number of intestinal concretions are chiefly formed of fatty matters, together with salts of potash and a small quantity of fibrin. We know not whether the fatty matter which they contain be derived from the food or from the intestinal secretions. We subjoin two analyses of such concretions:

	Lassaigne.	Robiquet.
Fatty matters	74	60
Animal matter	21	8
Phosphate of lime	1	30
Chloride of sodium	1	"

The concretions analyzed by M. Lassaigne, were found in the alvine evacuations of a young girl affected with phthisis.

4. OF THE GASES FOUND IN THE STOMACH AND INTESTINES.

Gas may occupy every portion of the gastro-intestinal tube. It is more especially met with in the cæcum, the colon (particularly the transverse colon), and the ileum. It is only as an exception, and while the act of digestion is going on, that it is found in the stomach.

The following gases are met with in the intestines: carbonic acid, nitrogen, pure hydrogen, carburetted hydrogen, sulphuretted hydrogen, and sometimes oxygen.

M. Chevreuil was one of the first to analyze the intestinal gases. The following are the results at which he arrived.*

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* Majendie's *Physiology*, vol. ii, p. 89.

A. GAS FOUND IN THE STOMACH.

On one occasion only, was a quantity found, sufficient for the purposes of analysis. 100 parts of this pus were thus composed:

Oxygen	11.00
Carbonic acid	14.00
Pure hydrogen	3.55
Nitrogen	71.45
	1000.00

B. INTESTINAL GASES.

	1. A man, 24 years of age. Having eaten bread and Gruyère cheese two hours before his execution.	2. A man, 25 years of age. circumstances similar to the preceding.	A man, 23 years of age. Having eaten beef, bread, and lentils, and drank wine, four hours before execution.	
Small intestine.				
Carbonic acid	24.39	40.00	25.00	
Pure hydrogen	55.53	51.13	8.40	
Nitrogen	20.08	8.85	66.60	
Large intestine.			*Cæcum.*	*Rectum.*
Carbonic acid	43.50	70.00	12.50	42.86
Carburetted hydrogen	5.47 a trace of sulphuretted hydrogen.	11.60	12.50	11.18
Pure hydrogen	0.00	a trace	7.50	0.00
Nitrogen	51.03	18.40	67.50	45.96

It is to M. Chevillot that we are indebted for the most complete and extended researches hitherto made, relative to the intestinal gases. We shall quote largely from these researches, as also from those of MM. Majendie, Chevreuil, and Jovine.

1. *Nitrogen.*—This is more especially found in the intestines of persons dying of disease. According to M. Chevillot, it constitutes the $\frac{90}{100}$ths of the gas met with, in those of a pale complexion, and in old persons exhausted by protracted disease.

2. *Carbonic Acid.*—This is also found in large proportion. In individuals dying from disease, it is, next to nitrogen, the most abundant of the intestinal gases. M. Chevillot has found as much as 92 to 93 per cent. He has, likewise, found it in much larger quantities in persons dying of acute diseases, or

of thoracic affections, than in those affected with chronic disease; the reverse holds good with respect to nitrogen.

In health, the carbonic acid decreases in quantity, from the stomach to the rectum. According to M. Chevillot, the proportion of carbonic acid found in the digestive organs of individuals dying of disease, diminishes gradually from the stomach to the small intestine, and increases from this latter to the rectum. If, however, in persons of from forty-six to seventy-two years of age, the gas be collected at a low temperature (32° to 40° Fah.), the quantity of carbonic acid diminishes from the stomach to the rectum.

3. *Pure Hydrogen* is less frequently met with in the large than in the small intestines, and in many cases it is found in neither. In sixty-nine persons dying of disease, it was detected by M. Chevillot fifty-eight times. The intestines of persons dying of phthisis contained, in general, but little hydrogen, and sometimes none; more, however, was met with in individuals dying either of acute disease or of affections of the digestive organs. It was also found in larger quantities in persons of a full habit, than in those who were emaciated. Lastly, the intestines of those who had made use of acid beverages, of æthers and alcoholic tinctures, contained less hydrogen than those of persons who had employed remedies of another description.

4. *Oxygen.*—We have already seen, that it was only met with in one of the three individuals executed.

In fifty-four individuals dying from disease, M. Chevillot found oxygen mingled with other gases thirty-one times; viz., twenty-five times in the stomach, five times in the large intestine, and once in the small intestines. It constituted from 2 to 3 per cent of the intestinal gases, and from 2 to 6, or even 8 per cent, of that found in the stomach. In one case it rose as high as 13 per cent.

Carburetted Hydrogen.—This gas was found by M. Chevillot in only ten out of ninety-six bodies examined by him; viz., once in the small, and nine times in the large intestines. The greatest proportion obtained was 18 per cent.

Sulphuretted Hydrogen.—This is the least abundant of the intestinal gases. Traces of it alone being occasionally discovered. Nevertheless, we cannot deny that, in many cases where digestion is imperfectly performed, the odour of the gas which escapes, indicates the production of a certain quantity of sulphuretted hydrogen.

We have thus given a sketch of the researches of M. Chevillot. The importance of the subject, however, induces us to subjoin a more complete *resumé* of his labours.

"1. *Oxygen.*—This gas does not invariably exist in the *primæ viæ*, and when met with, it is only in small quantity. Of fifty-one subjects experimented upon, thirty-one alone give indications of the presence of oxygen; viz., twenty-five in the stomach, five in the large, and one in the small intestines. In these last, the proportion was from 2 to 3 per cent.; in the stomach, from 2 to 8 per cent., and, on one occasion, 13 per cent. Neither temperature nor the age of the individual appear to produce any marked change in the quantity of oxygen.

The decrease, and even the complete disappearance, of this gas from the intestines, is a remarkable circumstance; it leads us to surmise that, in the majority of cases, it is either absorbed in the stomach, or enters into combination with other substances.

"2. *Nitrogen.*—Of all the gases met with in the digestive organs of individuals dying of disease, nitrogen is the most abundant; it exists in every portion of the canal, sometimes constituting 99 per cent. of the gases contained therein. More frequently, however, it is found in combination with those other gases of which we have already spoken, and in proportions which vary, according to the different portions of the intestinal tube which it occupies.

"*Of the Proportion of Nitrogen, in Relation to Age.*—The nitrogen was collected from fifteen subjects, whose ages varied from fourteen to twenty-four years, at a mean temperature of about 45° Fah. Its mean proportions were as follows: in the stomach, 66.3;* in the small intestine, 57.8; in the large intestine, 65.2. Again, the nitrogen having been collected from seventeen individuals, of from sixty to seventy-two years of age, its proportions were found to be as follows: in the stomach, 63.5† per cent.; in the small intestine, 66.8; in the large intestine, 73.

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* In nine of these cases only, was the nitrogen taken from the stomach.

These results prove, that nitrogen is more abundant in old persons than in adults. In order to ascertain whether this were in any way dependent on difference of temperature, we collected, at a temperature of from 54° to 70° Fah., the nitrogen found in the intestines of twenty-four individuals, of from fifteen to seventy-one years of age; the mean being forty-one. We obtained, on the average, 62.6 from the small intestine, and 60.6 from the large intestine. Again, we collected (at a temperature of from 28° to 38° Fah.) the nitrogen from the bodies of twenty-four persons, of from fourteen to sixty-four years of age (mean 35.5), and obtained, on an average, 77.7 from the small, and 77.0 from the large intestine. It appears, therefore, from these experiments, that at a temperature of from 28° to 38° Fah., the intestines of persons of from fourteen to sixty-nine years of age, contain more nitrogen than at a temperature of from 54° to 70° Fah.

"*Influence of Temperature in Old Persons as Compared with Adults.*—The nitrogen was collected from the stomach and intestines of five persons, of from seventeen to twenty-three years of age, and at a temperature of from 34° to 40° Fah. The mean proportions obtained were: in the stomach, 74.6; in the small intestine, 79.2; in the large intestine, 86. The amount of nitrogen found in the digestive organs of five individuals, of from eighteen to thirty years of age, at a temperature of from 47° to 61° Fah., was, on the average, as follows: in the stomach, 49.8; in the small intestine, 36.4; and in the large intestine, 28.4. Here, the difference of temperature produced a corresponding difference in the proportion of nitrogen. The greatest quantity being found at a low temperature.

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* In ten of these cases only, was it taken from the stomach.

" The proportion of nitrogen found in the digestive organs of eight persons, aged from sixty to sixty-seven years, and at a temperature of from 52° to 70° Fah., was as follows; in the stomach, 76; in the small intestine, 72.2; and in the large intestine, 75.4. In seven other cases, the ages being similar, the proportion of nitrogen at from 34° to 43° Fah. was as follows: in the stomach, 55; in the small intestine, 61.4; and in the large intestine, 59.

"It would appear, therefore, from these experiments, that the digestive organs of persons of from sixty to seventy years of age, contain more nitrogen at a temperature of from 52° to 70° Fah., than at a temperature of from 34° to 43° Fah.; being just the reverse of what takes place between eighteen and thirty years of age.

"It might be supposed, that the changes produced in the digestive organs by disease or symptomatic disturbance, would cause some difference in the quantity of nitrogen contained therein; to ascertain whether this were really the case, the diseases of twelve individuals, whose digestive organs contained the smallest amount of gas, were compared with one another.

" Of these twelve persons, aged from seventeen to sixty years, and whose intestines had afforded the smallest per-centage of nitrogen at a mean temperature of 49°, one had been the subject of apoplexy; another, of confluent small-pox and pneumonia; one, of croup; three, of pleurisy; two, of cardiac hypertrophy; three, of peritonitis; and one, of ulceration of the intestines.

" Of twelve persons, of from twenty-three to sixty-one years of age, who had afforded the greatest amount of nitrogen at a mean temperature of 43° Fah., one died from aortic aneurism; another, from hypertrophy of the heart, with anasarca and slight gastritis; a third, from cancer of the intestines; eight, from phthisis; and one, from severe disease, the exact nature of which was not ascertained.

"These cases tend to prove, that the intestines of adults affected with acute diseases, contain, in general, but little nitrogen, and that this gas is especially met with in older individuals, the subjects of chronic disease.

"As for the relative proportions of nitrogen existing in the different parts of the digestive canal, the following data have been obtained.

"1. That the amount of nitrogen is, in general, greater in the last than in the first portions of the gastro-intestinal tube.

"2. That, in both adults and old persons, the quantity of nitrogen oftener increases than diminishes, at a temperature of from 27° to 37° Fah., and that the decrease is less marked in adults than in old persons.

"3. That, at a temperature of from 38° to 47° Fah., in the aged, the quantity of nitrogen does not vary much from the stomach to the intestines, but that it becomes greatly increased on passing from the small to the large intestine.

"4. That, at a temperature of from 34° to 61° Fah., the increase of the nitrogen is greater than its decrease, in persons of from fourteen to twenty-six years of age; and, that the contrary is the case in those of from forty-eight to sixty-four years of age, at a similar temperature.

"3. *Carbonic Acid Gas.*—This is, after nitrogen, the most abundant of the gases found in the digestive organs in disease, being constantly met with there; I have never, however, been able to discover it in two parts of the small intestine, although existing in the large intestines of the same individual. The greatest amount obtained has been about 92 or 93 per cent. This gas deserves special attention, by reason of the important part which it plays in the animal economy, whether on account of its quantity, or of the promptitude with which it is either developed or absorbed in many cases of meteorismus. We shall consider it with reference to age and temperature, as well as to the nature of the disease, and to its variations in quantity, in the different parts of the digestive tube.

"*Temperature.*—At a mean temperature of 56° Fah., in nine subjects, aged from thirty-six to seventy-seven years, the quantity of carbonic acid found in the small intestines was 54.33: in the large intestines, 51.77.

"On the other hand, at a mean temperature of 35° Fah., the amount of carbonic acid found in nine subjects, of the same age as the preceding, was as follows: viz., 7.44 in the small, and 4.22 in the large intestines. Hence it follows, that at a temperature of 56° Fah., the amount of carbonic acid found in the large and small intestine is seven times greater than at a temperature of 35° Fah.

"*Age.*—As regards age, it follows, from experiments made upon seventeen individuals, of from sixty to seventy-two years of age, at a mean temperature of 47° Fah., and upon fifteen others, of from fourteen to twenty-four, at a mean temperature of 45° Fah., that in adults, the quantity of carbonic acid gas found in the small and large intestines is more than double that found in the intestines of the aged.

"*Diseases.*—The greatest quantity of carbonic acid gas is found in subjects that have been affected with acute diseases of the lungs. Those affected with chronic disease afford the smallest proportion of the gas in question.

"*Of the different proportions of carbonic acid gas, found in the different parts of the digestive canal.*—Upon this point physiologists are not as yet agreed. According to M. Juvine, the quantity of gas diminishes from the stomach to the intestines; while, according to Majendie and Chevreuil, the reverse is the case. It was of importance, therefore, to decide the question, and, with this view, the carbonic acid found in the digestive organs was carefully examined, with the following results; due attention having been paid to the temperature and age of the subjects of experiment.

"1. It was found, that in persons of from fourteen to seventy-two years of age, at a temperature of from about 36° to 71° Fah., the carbonic acid increases from the small to the large intestines, in the proportion of 35 to 48, and that it decreases from the stomach to the intestines in the proportion of 3 to 2.

"2. That, at a temperature of about 40° Fah., in persons of from fourteen to seventy-two years of age, the amount of carbonic acid is the same in the small as in the large intestines and that it diminishes from the stomach to the intestines, in the proportion of 2 to 1.

"3. That, at a temperature of from 52° to 71° Fah., in persons of from fifteen to seventy-two years of age, the carbonic acid increases, from the large to the small intestines, in the proportion of 1 to 2.25, and that it diminishes, in the proportion of 2 to 1, from the stomach to the small intestines.

"4. That, at from 28° to 41° Fah., in those of from sixteen to twenty-five years of age, the carbonic acid increases from the small to the large intestine, in the proportion of 1 to 3, and that it diminishes in the same subjects, in the proportion of 6 to 1 from the stomach to the small intestines.

"5. That, at from 26° to 40° Fah., and between the ages of forty-six and seventy-two, the carbonic acid decreases from the small to the large intestine, in the proportion of 3 to 2, and in that of 6 to 1 from the stomach to the small intestine.

"6. That, at from 52° to 63° Fah., and between the ages of fifteen and thirty-six, the carbonic acid increases, in the proportion of 1 to 2, from the small to the large intestines, and that it decreases, in the proportion of 3 to 1, from the stomach to the small intestines.

"7. That, at from 52° to 71° Fah., and between the ages of fifty and seventy-one, the carbonic acid increases from the small to the large intestines, in the proportion of 4 to 3; and that at from 52° to 63° Fah., in persons of from fifteen to sixty-seven years of age, the proportion of carbonic acid gas varies but little.

"4. *Hydrogen.*—This gas is not so frequently met with in the digestive organs of persons suffering from disease, as is nitrogen or carbonic acid: of sixty-nine subjects examined, fifty-eight only afforded indications of its presence. We have found it in the proportion of from 0.55 to 0.56. It was most abundant in robust, plethoric adults.

"With reference to the influence of temperature upon the quantity of hydrogen, experience has shewn that, at a temperature of from 28° to 46° Fah., less of this gas is found, than at a temperature of from 52° to 70° Fah.

"As regards age, we have ascertained: 1. That, between the ages of seventeen and thirty, the quantity of hydrogen is three times greater at a temperature of from 52° to 62°, than between the ages of sixteen and twenty, at a temperature of from 30° to 40° Fah.; and 2. That in old age, the hydrogen is less abundant at a temperature of from 52° to 59° Fah., than at one under 44°; a result diametrically opposite to that obtained, under similar circumstances, between the ages of sixteen and thirty.

"*Diseases.*—Of twenty-one subjects examined, and in whom little or no nitrogen was found, seven afforded evidence of severe disease; one, of apoplexy; nine, of phthisis; one, of pleurisy; one, of hypertrophy of the heart; one, of aneurism of the aorta; and one, of cancer of the liver.

"Of twenty-one cases where a large amount of hydrogen was found, one had died of a severe disease; two, of apoplexy; one, of croup; one, of pulmonary catarrh; one, of pleurisy; one, of pneumonia; one, of phthisis; two, of hypertrophy of the heart; two, of small-pox; two, of cancer; one, of ascites; one, of gastritis; one, of peritonitis; and one, of enteritis.

"These experiments tend to show, that those who have fallen victims to phthisis, afford, in general, but a small amount of hydrogen; and that this gas, moreover, is found especially in those who have died of acute diseases, or of affections of the digestive organs.

"The nature of the food and medicines administered to the patients, appears to exercise considerable influence upon the production of hydrogen; but it is difficult to ascertain this with accuracy, on account of the diversity of these agents. Nevertheless, on comparing the food and medicines taken by eighteen individuals, who, after death, afforded either little or no hydrogen, with those taken by eighteen others, in whom a large amount of this gas was discovered, we find that these latter had taken arnica, senna, angelica root, ipecacuanha, Morton's pills, veal, and other articles of hospital diet; while the remaining eighteen, who had afforded but little hydrogen, made use of vinegar, tartaric acid, couch grass, digitalis, squill, catechu, extract of soap-wort, syrup of pinks, tincture of assafœtida, æther, and eggs. Hence we may conclude, that in general, acid vegetables, and spirituous or ætherial liquids, either impede the development of hydrogen, or give rise to but a small amount of this gas.

"*Of the proportion of hydrogen in the different parts of the digestive canal.*—It is more abundant in the small intestines than in the stomach or large intestines.

"5. *Carburetted hydrogen* is not unfrequently met with in disease, but in smaller proportions than the preceding gas, with which it is always found mixed. It was found in ten only out of ninety-eight cases; once in the small and nine times in the large intestine. The largest amount which we have been enabled to collect was 18.8 per cent. It was chiefly found in adults labouring under acute disease.

"6. *Sulphuretted hydrogen.*—From the fœtid odour arising from the alvine evacuations in many diseases, it might be supposed, that large quantities of sulphuretted hydrogen existed in the digestive organs; in such cases, however, experiments merely afford traces of this gas. It is otherwise, on submitting to a temperature of from 97° to 105°, and in a closed vessel the matters contained in the alimentary canal; in this manner we have always been enabled to collect a certain quantity of sulphuretted hydrogen."

The foregoing researches serve, therefore, to prove:

"1. That in disease, six different kinds of gas are met with in the digestive canal.

"2. That nitrogen is found in larger quantity in the diseased than in the healthy body; the reverse being frequently the case, as regards carbonic acid.

"3. That the carbonic acid in disease, increases in quantity, at a temperature of from about 50° to 70° Fah., and that it decreases at a temperature of from about 27° to 37° Fah.

"4. That in adult subjects, the proportion of hydrogen gas is greater at a temperature of from 52° to 62° Fah., than at from 34° to 43° Fah.; whilst the reverse holds good in the aged, under similar conditions of temperature.

"5. That hydrogen is more abundant in the small intestines than in the stomach or large intestines, and that, therefore, a gradual increase in quantity, from the former to the latter, does not actually take place, as has been hitherto asserted."*

The quantity of gas contained in the digestive canal increases under certain circumstances. We shall not enter into detail respecting these, but content ourselves with a short summary of the causes which may give rise to this increase.

1. When there is an obstacle to the onward progress of the contents of the intestinal tube, such as a stricture, a hernia, etc., the gases accumulate in that portion of the canal which is above the seat of stricture.

2. In certain affections of the digestive organs: gastralgia, gastro-enteralgia, gastric derangement, enteritis, and entero-colitis, an increase in the quantity of gas takes place.

3. Under the influence of certain articles of food, the quantity of gas increases. Thus, substances which are not affected by the secreted fluids of the digestive organs (the gastric and pancreatic juice—the bile) sometimes produce this result.

4. In some general affections of the nervous system, very considerable accumulations of gas not unfrequently occur; this is especially the case in chlorosis and hysteria.

Great differences of opinion have existed, relative to the origin of the gases found in the digestive organs. We shall not, however, enter into any discussion upon the subject, contenting ourselves with stating, that the evolution of these gases is due to the mutual reaction upon one another of the matters contained in these organs.

SECT. IX.—Of the Nasal Mucus.

All that we have previously stated respecting mucus in general, is applicable to the variety in question. There is one point, however, requiring special notice.

In the early stage of coryza, or in that, rather, which follows the sensation of dryness in the nasal fossæ, there flows from the mucous membrane a thin, transparent, saline, and somewhat irritating fluid. This latter quality is sometimes so marked, as to inflame and even excoriate the upper lip. The mucus derived from the nasal fossæ appears to possess this irritating quality in a higher degree than the secretion of other mucous membranes. The cause of this phenomenon may readily be determined, and close investigation demonstrates the nature of this product. It is a slightly muco-albuminous fluid, composed of mucus, properly so called (mucine), and of albuminous serosity, less rich, however, in albumen than the serum of the blood. No quantitative analysis has, as yet, been made, relative to this secretion from the mucous membrane of the nostrils in the early stage of coryza; we need scarcely say, that it is soon replaced by a discharge of muco-pus.

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* *Gazette Médicale*, 1833.

Sect. X.—Of the Uterine Mucus.

The mucus secreted by the lining membrane of the uterus, presents itself under very different conditions.

Four varieties of uterine mucus may be distinguished. These we shall now consider in succession.

1. *Pure mucus.*—At the free orifice of the neck of the uterus, we sometimes observe a stringy, viscid mucus, almost transparent. It evidently escapes from the cavity of the womb.

This variety is entirely composed of water, mucine, and a very small quantity of alkaline salts. The microscope detects merely a few epithelial cells.

This secretion may be the produce of a thoroughly healthy uterus. It is not, however, necessarily secreted by all such. On the other hand, we have observed it in women in whom the neck of the uterus was dilated, and the orifice somewhat redder than natural; manifestly shewing a slight degree of congestion, with irritation of the lining membrane of the organ. This is, however, rare, and, in the great majority of cases, this transparent, stringy, viscid mucus is the secreted product of a healthy uterine mucous membrane.

2. *Opaline mucus.*—This variety is more frequently met with than the former. It is somewhat less viscid, more abundant, and of a whitish, milky, opaline aspect. It evidently escapes from the orifice of the uterus, but the vaginal mucous membrane, and more especially that which lines the posterior walls of the canal, almost always secretes an absolutely similar fluid.

The microscope reveals the presence of a large number of epithelial cells, to which the lactescence or opalinity of the fluid is due.

It is composed of water, mucine, fragments of epithelium, and alkaline salts, more especially chloride of sodium.

Opaline mucus is almost always the result of some fault of secretion on the part of the uterine and vaginal mucous membranes. It constitutes the leucorrhœal discharge, properly so called; a discharge which may exist without our being able to detect any trace of inflammation in the lining membranes of the uterus and vagina.

This variety of uterine mucus, when recently examined, is neutral or alkaline. When treated with water and filtered, the transparent fluid which passes through, contains no trace of albumen, and the proportion of fatty matters is very small.

3. *Muco-pus.*—Whenever the mucous membrane of the neck or body of the uterus is inflamed, without being ulcerated; and whenever the lining membrane of the vagina is in a similar condition, as in acute or chronic vaginitis, this variety of mucus constitutes the ordinary secretion of the part.

When recently examined, it is a thick, stringy, viscid fluid, of a yellow, or yellowish-green colour, slightly alkaline, and in every respect similar to the muco-pus previously described.

It contains mucine, epithelial cells, numerous pus globules, and a larger proportion of fatty matters than the two other varieties of uterine mucus. It burns with a bright light, while transparent and opaline mucus merely become carbonized.

It is to Güterbock that we owe a knowledge of this fact, as regards mucus in general, whilst we ourselves have applied it to the investigation of the uterine and vaginal muco-pus. It is, however, one of little importance; and, as a rule, inspection alone is sufficient to distinguish these varieties from one another.

This muco-pus when treated with water, agitated and filtered, does not impart a trace of albumen to the transparent fluid which passes through. Should any be discovered, it must be attributed to one or more ulcerations of the mucous membrane lining the neck of the uterus.

This is the true characteristic which distinguishes simple muco-pus from muco-pus when mixed with true pus, more especially as regards the vaginal and uterine mucous membranes; for the mucous membrane of the bronchial tubes sometimes contains a very small quantity of albumen, much smaller, indeed, than that which, as we have before stated, is met with in true purulent mucus.

Pure muco-pus necessarily indicates the existence of inflammation, either in the body or neck of the uterus, or in the vagina; being, in other words, exactly similar to that of which we have already spoken, when treating of the secreted products of mucous membranes in general.

4. *Purulent mucus, properly so called.*—This variety always denotes the existence of ulcerations, which are either situated upon the surface of the neck of the uterus, or upon the mucous membrane by which it is lined; more rarely, on the vaginal mucous membrane itself.

This variety differs from the preceding in two respects.

1. The pus with which muco-pus is mingled, introduces into this latter a larger proportion of fatty matters, and a small quantity of albumen. This fluid, when treated with a small quantity of distilled water, well shaken, and then filtered, allows a transparent liquid to pass through, which, on the application of heat and nitric acid, precipitates flakes of coagulated albumen. This latter phenomenon is of great importance, and we lay much stress upon it, since, whenever it is met with, we must, of necessity, admit the presence of ulcerations, which, even if not detected, actually exist upon the mucous membrane lining the neck of the uterus. We con-

ceive this to be a most valuable diagnostic sign, and one which cannot be too strongly impressed upon the minds of medical practitioners.

In addition to the different matters which we have just mentioned as existing in uterine mucus and muco-pus, M. Donné has, in certain cases, noticed a large number of infusorial animalcules. These infusoria, the form and structure of which at once resemble that of both the *monades* and *trichodes*, have received the name of *trichomonas vaginalis.* It would appear, from the researches of M. Donné, that they are only found in discharges that are of syphilitic origin.

In this way, says M. Donné, we may readily establish the differential diagnosis of the various discharges arising from the vagina: of these he distinguishes three species.

a. Simple, or catarrhal vaginal discharge, composed of vesicles, more or less agglomerated, without globules, and reddening litmus paper.

b. A non-syphilitic purulent discharge, composed of vesicles and pus globules, but always devoid of *trichomonas.*

c. Syphilitic, or gonorrhœal purulent discharge, distinguished from the preceding variety by the presence of the *trichomonas.*

All this may possibly be true, but it is not as yet thoroughly established. Many observers regard the presence of infusoria as indicative, merely, of commencing decomposition on the part of the vaginal fluid. We conceive, however, that the above facts require reinvestigation, and that we are not in a position, at present, either to admit or reject *in toto* the views of M. Donné.

ARTICLE II.

OF THE PRODUCTS OF SEROUS MEMBRANES.

In health, the quantity of fluid which serves to lubricate the serous membranes, is so small, that to attempt its analysis would be absolutely useless.

We have here, therefore, to consider only the pathological products of these membranes.

Two species of fluid may exist in the serous cavities; these require to be noticed under distinct heads.

The first comprehends dropsical collections properly so called,—collections formed without inflammation of the serous tissue itself.

The second comprises those fluids which result from inflammation of the serous membranes. To these, Vogel has given the name of fibrinous dropsy.

SECT. I.—Dropsical Fluids properly so called.

Under this head, are comprised the fluids which accumulate under the influence of the many different causes giving rise to dropsy, without either local disease, or inflammation of the serous membranes. These, as is well known, may be referred to two groups.

1. Dropsy depending on some mechanical obstacle to the circulation;

2. Dropsy due to a modification of the blood.

MM. Andral and Gavarret have carefully analyzed the fluid of dropsy, and to them we are indebted for a knowledge of the following important fact, viz., that this fluid is identical in composition with the serum of the blood, except that it contains a much smaller proportion of albumen. The chemical constituents, however, are the same in each.

Having ourselves made numerous analyses of dropsical fluid, the following are the conclusions at which we have arrived:

1. Whenever fluid accumulates in a serous cavity, or in cellular tissue, so as to constitute dropsy, this same fluid is found to be nothing more than a serosity, analogous to the serum of the blood. The albumen, salts, fatty, and extractive matters, are of a similar nature; their proportion, however, is always less than in the serum of the blood; the same, therefore, may be said of their specific gravity. Sometimes, however, this fluid contains a much larger amount of cholesterine than the serum of the blood.

2. Whenever dropsy is the result of a mechanical obstacle to the circulation of the blood, whether this obstacle be seated in the central organ of the circulation, or in a large vein, the composition of the effused or infiltrated fluid is richer than in those cases where the cause of the dropsy lies in some modification of the blood; its specific gravity, therefore, is higher.

3. Whenever dropsy is the result of some modification of the blood, the quantity of albumen, salts, fatty, and extractive matters, is always much less than in the preceding case; in Bright's disease, for example, the fluid is sometimes only found to contain a very small per centage of albumen.

4. In different individuals, affected with the same disease, the composition of the dropsical fluid is never absolutely identical. It varies with the composition of the blood. Of the relationship existing between them, however, we know nothing.

5. When the fluid is removed from the same patient at different periods (as when tapping is performed at certain intervals), its composition is never found to be the same. In general, the fluid contains less and less albumen, in proportion to the frequency of the operation, and to the length of time which has elapsed since the commencement of the disease.

6. If dropsical fluid be taken from different parts of the same individual, even at the same moment of time, its composition will be found to differ. Thus, the proportion of albumen, and, consequently, the specific gravity, decrease in the following older:

1. The peritoneum; the fluid in this cavity always containing the largest amount of albumen;
2. The pleura;
3. The pericardium;
4. The cellular tissue;
5. Whenever a small quantity of fluid is found in the ventricles of the brain, the proportion of albumen is at its *minimum*, and, indeed, not unfrequently inappreciable.

We shall choose from among our numerous analyses, a few examples, serving to demonstrate the truth of the above propositions.

1. *Fluid removed by the operation of paracentesis abdominis.*

	Density.	Water.	Albumen.	Extractive matters.
1. A man, aged 45; ascites and general anasarca, symptomatic of cardiac disease	1012.20	982.79	17.21	10.84
2. A man, aged 51; cirrhosis of the liver	1014.00	976.50	23.50	19.27
3. A woman, aged 53; disease of the heart, ascites, and general anasarca	1019.50	966.00	34.00	19.30
4. Ditto, aged 31 years; ascites, depending on an encysted dropsy .	1009.60	980.26	19.74	5.61
5. Ditto, aged 27; ascites apparently idiopathic. The patient left the hospital	1005.23	985.61	11.15	3.24
6. Ditto, aged —; ascites, depending on cirrhosis of the liver . . .	1013.82	976.39	23.61	13.75

2. *Fluid removed from the body of a man who had died of Bright's disease.*

	Density.	Water.	Albumen.	Extractive matters.
Fluid removed from the lower extremities in a state of infiltration .	1002.11	993.17	5.38	1.45
Ditto ditto, from the thoracic cavity (hydrothorax)	1003.82	980.69	8.36	1.95
Ditto ditto, from the abdominal cavity (ascites)	1005.88	985.57	11.88	2.55

We shall now quote a few analyses made by Simon. They serve to give a still more complete idea of the composition of dropsical fluids:

Analysis of the fluid effused in acute hydrocephalus.

	Berzelius.	Mulder.	Marchand.	
			1.	2.
Water	988.30	989.997	986.54	989.93
Solid matters . . .	11.70	10.003	13.46	10.07
Albumen	1.66	0.649	1.10	1.02
Fat	„	0.070	0.05	0.33*
Alcoholic extract, with lactate of soda . . .	2.32	2.538	2.10	3.21
Watery extract . .	0.26	„	0.13	„
Chlorides of sodium and potassium . . .	7.09	6.553	7.87	5.28
Earthy phosphates . .	0.09	0.090	0.10	0.23
Sulphate of soda . .	„	0.146	0.11	
Carbonate of soda . .	„	0.057		
Soda	0.28	„	„	„

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* The proportion of cholesterine was 0.21.

Analysis of fluid removed from the abdomen of a woman by paracentesis.

(Marchand found in it a large amount of urea.)

Water	952.2
Solid constituents	47.8
Albumen	23.8
Urea	4.2
Chloride of sodium	8.1
Carbonate of soda	2.1
Phosphate, and traces of sulphate of soda	0.6
A viscid substance	8.9

Fluid of ascites analyzed by Heller.

(A milky looking liquid, neutral, inodorous ; specific gravity, 1.007.)

Water	950.00
Solid constituents	50.00
Extractive matters and traces of albumen	5.97
Fat	0.84
Fixed salts, chiefly chloride of sodium	44.00

Analysis of fluid in a case of ascites complicating Bright's disease.

(Heller.)

Water	980.640
Solid constituents	19.360
Albumen	8.121
Fat	0.220
Soda soap	0.392
Extractive matters	2.546
Fixed salts	8.080

(There were no traces either of urea or cholesterine.)

Analysis of a similar fluid by Percy.

Water	952.0
Solid matters	48.0
Albumen	38.0
Undetermined organic matter	3.2
Salts	7.6

Analysis of the fluid extracted by paracentesis from the abdomen of a man in whom suppuration of the kidneys was discovered after death.

(Simon.)

Specific gravity	1010.0
Water	978.0
Solid matters	12.0
Fat containing cholesterine	1.0

Albumen	8.4
Alcoholic extract	0.3
Aqueous extract	1.7
Carbonate of soda and phosphate of lime	1.2
Urea	1.2
Chloride of sodium and lactate of soda	1.2

Analysis of the fluid found in the inferior extremities of an individual affected with Bright's disease of the kidney. (*Simon.*)

(This fluid contained urea, together with a large quantity of albumen and chloride of sodium.)

Specific gravity	1012.0
Water	976.0
Solid matters	24.0
Fat containing cholesterine	0.5
Albumen	7.0
Alcoholic extract with urea	2.0
Alcoholic extract	1.9
Watery extract	3.0
Carbonate of soda and phosphate of lime	1.0
Chloride of sodium and lactate of soda	8.1

Analysis of two specimens of dropsical fluid removed from the lower extremities. (*Heller.*)

	1.	2.
Water	986.934	975.20
Solid constituents	13.066	24.80
Extractive matter, with an imponderable amount of albumen and urea	4.226	„
Fixed salts	8.840	15.62
Free albumen	„	5.42
Extractive matter, uncombined and saponified fat, with urea	„	3.76

Analysis of fluid found in a certain number of cases of hydrocele.

(In one of these a large amount of cholesterine was found. (Simon.)

Water	860.00
Solid matters	140.00
Cholesterine, with a little margarine and oleic acid	8.40
Albumen	48.30
Albuminate of soda and extractive matters	6.88
Extractive matter, soluble in alcohol	2.30
Chlorides of sodium and calcium, a little sulphate, with traces of phosphate of lime	72.52
Phosphate of lime, with traces of peroxide of iron	0.70

We are indebted to Heller for three analyses of the fluid of hydrocele.

First analysis, in a man sixty-five years of age.

(An alkaline liquid.)

Specific gravity	1021.0
Water	919.2
Solid constituents	80.8
Albumen	58.0
Free fat	1.6
Soda soap, biliphæin, hemato-globulin, dissolved hæmatin, and extractives	13.9
Fixed salts	7.3

Second analysis, a man thirty years of age.

(An alkaline liquid.)

Specific gravity	1020.00
Water	934.00
Solid matters	66.00
Albumen	52.81
Fixed salts, especially chloride of sodium	7.68
Fat, without cholesterine	0.14
Watery extract	1.17
Soda soap, biliary resin and pigment, urea, uric acid, and alcoholic extract	4.20

Third analysis, a man fifty years of age.

(An alkaline liquid.)

Specific gravity	1020.00
Water	906.36
Solid matters	93.64
Albumen	60.00
Fat, containing cholesterine	0.23
Extractive matters, biliphæin, and soda soap	24.04
Fixed salts, especially chloride of sodium	9.37

The following analysis of the fluid of hydrocele was made by Percy.

Water	927.4
Solid matters	74.6
Albumen	59.2
Fat	a trace
Alcoholic extract	1.2

Aqueous extract	2.2
Chloride of sodium, with traces of chloride of potassium	6.0
Soda and lime, with sulphuric, carbonic, and phosphoric acid	4.0

Sect. II.—Sero-fibrinous fluid.

We have stated in the foregoing article, that the fluids constituting dropsy are always composed of serum, diluted with a certain quantity of water; and that this is, moreover, the case in each of the two great classes of dropsy—*dropsy from mechanical obstruction to the circulation*, and *dropsy from alteration of the blood* (decrease of the albumen). We have also seen, that in neither of these varieties is fibrin met with. Such, however, is not the opinion of Vogel, who admits the possibility of the existence of fibrin in dropsical effusions. This conclusion we cannot adopt, and it would appear from our own researches, that whenever fibrin is found in the serum of dropsy, inflammation must, at some time or another, have been present in the tissues from which the effusion has taken place.

To this sero-fibrinous fluid, Vogel has given the name of fibrinous dropsy. We reject the expression, however, inasmuch as it would seem to establish a connexion between the dropsy and the presence of the fibrin; and this connexion can only be admitted in certain exceptional cases, where the part affected with dropsy becomes subsequently the seat of inflammatory action, as may sometimes occur: we here, however, speak merely of fluids examined shortly after their formation, and, for this reason, we prefer the term, *sero-fibrinous fluid*, as in no way presupposing the nature of the cause by which it has been produced.

We now proceed to investigate the fluid designated by Vogel as fibrinous dropsy, and by ourselves as sero-fibrinous effusion.

It differs considerably from simple albuminous fluid.

Chemical composition.—The qualities of this sero-fibrinous fluid are the same, whether it be effused into the tissues of an organ, or into a serous cavity.

When examined shortly after being evacuated, it resembles the ordinary albuminous fluid of dropsy; sometimes it is limpid and colourless, at others, it is yellowish green in colour, slightly tinted and opaline. Pus corpuscles are but rarely found in it.

After the lapse of a certain time, the fibrin coagulates and the fluid assumes the appearance of a homogeneous, gelatinous mass, which gradually contracts, diminishes in volume, and forms a firmer clot, of a yellow or yellowish red colour; this, when washed, squeezed, and dried, affords solid fibrin, in every respect similar to that of the blood. This coagulated fibrin presents, under the microscope, the appearance of an amorphous mass, entirely destitute of cells.

As regards composition, this sero-fibrinous fluid is analogous to serum of blood that has retained its fibrin but lost its globules; the proportion, however, of albumen and fibrin is never equal to that of the blood, whether considered in general, or as compared with that of the individual from whom the sero-fibrinous liquid has been obtained.

We have never found as large a proportion of albumen in this fluid as in healthy serum. Vogel, however, quotes an analysis of M. Quevenne's, in which this was actually the case.

It is different with regard to the fibrin, and here three cases may present themselves. There may be: 1. Decrease of the fibrin; 2. An identity of proportion between the fibrin of the effused fluid and that of the blood; 3. An increase of the fibrin of this same fluid, so as to exceed the proportion naturally existing in the blood.

The fibrin which exists in the sero-fibrinous fluid may, while still contained in the living body, undergo various modifications. These are as follows:

1. The fibrin may coagulate in the cavity containing the fluid, and in this case we meet with scattered albuminous flakes. Generally speaking, this coagulation affects only a portion of the fibrin.

2. The fibrin is converted into pus globules; or, rather, pus corpuscles are formed in the effused fluid, at the expense of the

fibrin contained therein. This transformation, again, is, for the most part, only partial.

3. The fibrin coagulates, but in becoming organized, it constitutes the basis of false membranes, *i.e.*, of those fibrinous flakes which, when deposited upon the surface affording the effused fluid, present a nidus for ulterior organization. It is this which forms those organized false membranes, cellular membranes, and adhesions, which succeed the effusion of sero-fibrinous liquid. And here we perceive the great difference which exists between the false membranes formed on the mucous and serous surfaces: the former never become organized, whilst the latter always, or at least almost always, do so.

As regards the various combinations which these divers transformations may form, observation demonstrates the following:

1. *A simple sero-fibrinous fluid.*—Here, the fibrin subsequently coagulates, and the product of coagulation becomes so organized, as to constitute false cellular membranes, which alone remain after the absorption of the albuminous fluid.

2. *A fluid, which is at first sero-fibrinous, but at length becomes entirely purulent, without the formation of organizable false membranes.*—This is observed in certain forms of pleurisy and peritonitis; more especially that which attacks women in child-bed.

3. *A sero-fibrinous fluid, in which one portion of the fibrin is converted into organizable false membranes, and another into pus globules.*—These changes may occur in the same individual; as, for example, in numerous cases of subacute pleurisy and peritonitis. Sero-fibrinous effusion is met with after many of the phlegmasiæ; it is the fluid which precedes pus, whenever this latter transformation is about to be effected. It cannot be formed in any organ, as we have before stated, without the pre-existence of a certain amount of inflammatory action. Thus, in inflammation of the cellular tissue, infiltration of the parts with sero-fibrinous effusion often takes place with great rapidity, and always precedes suppuration.

In pleurisy, peritonitis, and pericarditis, sero-fibrinous effusion is an almost constant and characteristic phenomenon. The three varieties before mentioned may, in such cases, be present; we should state, however, that it is only in certain special conditions, that sero-fibrinous fluid is transformed into pus. Thus, in purulent infection, in puerperal diseases, in some forms of pleurisy, peritonitis, and pericarditis, its conversion into pus is most rapid, and oftentimes almost complete.

The fluid found in the vesicles of a blister is a pure sero-fibrinous fluid. It is almost entirely composed of the serum of the blood, holding in solution fibrin, which soon coagulates and is converted, immediately under the skin, into a gelatinous liquid.

In the bullæ of pemphigus, of rupia, and of certain cases of erysipelas, the fluid contains but a very small quantity of fibrin. In the pustules of ecthyma, impetigo, variola, and varioloid, it contains a small proportion of fibrin and a certain number of pus glubules; occasionally these last predominate.

It may be laid down as a general rule, that whenever fibrin is met with in effused fluids, inflammation either is or has been present in the organ which is the seat of the effusion.

Certain facts, however, seem to prove, that this is not always the case; but the exception is only an apparent one. In some forms of simple dropsy, such as anasarca, and especially hydrothorax, ascites, hydropericardium, there is developed, consecutively, an inflammation of the membrane from which the effusion has taken place. In this manner are formed subcutaneous phlegmons, pleurisy, peritonitis, and pericarditis, where there already existed anasarca, hydrothorax, ascites, or hydropericardium. It is then only, that the nature of the effused fluid undergoes a change, and, from being merely albuminous, it now becomes sero-fibrinous, and therefore subject to the various modifications of which we have already spoken.

We shall now quote a few analyses in support of the preceding statements,

Vogel gives the following table, relative to what he designates as *fibrinous dropsy*.

	1. Blood Plasma.	2. Empyema.	3. Empyema.			4. Empyema.		Ascites.
			a.	b.	c.	a.	b.	
Water . .	906	983.5	945.6	953.	941	935.5	936	881
Fibrin . .	3.4	1.7	1.09	0.01	..	0.62	0.60	83
Albumen .	77	77.5	47.3	32	42.2	49.8	52.8	27
Extractive matters	3	..	..	6	7.2	3.4	1.6	9
Fat . . .	3	17	6			2.1	1.4	
Salts . . .	8	..	..	8	8.1	8	7.4	..

We quote, from Simon's treatise, the following analyses made by Scherer; the two first refer to an individual affected with chronic peritonitis, complicating cancer of the liver and stomach, the three following were made upon fluid removed from the thorax in a case, the details of which are not given.

	First Case.		Second Case.		
	1.	2.	1.	2.	3.
Water . . .	952.99	960.49	935.52	936.06	928.00
Solid matters .	47.01	39.51	64.48	63.94	72.00
Fibrin . . .	0.32	"	0.62	0.60	"
Albumen . .	11.88	"	"	"	52.00
Albuminate of soda	22.70	29.73	49.77	52.78	"
Extractive matters	3.02	2.12	3.46	1.61	7.40
Fat . . .	1.26	1.63	2.14	1.35	2.04
Salts . . .	7.22	5.94	7.93	7.40	10.02

Analysis of an alkaline fluid removed from the thorax of an individual suffering from hydrothorax, or probably from acute pleurisy. (*Simon.*)

(The details are wanting.)

Specific gravity	1022.04
Water	934.72
Solid matters	63.28
Fibrin	1.02
Fat	1.05
Alcoholic extract with salts	1.35
Ætherial extract with salts	10.64
Albuminate of soda	17.86
Albumen	31.00
Fixed salts	9.50

Scherer has published nine analyses of fluids found in cases of peritonitis and metro-peritonitis. In these, the conversion of albumen into fibrin was, in all probability, complete.

	1. Peritonitis complicating cancer of the liver.	2. Metro-peritonitis and broncho-pneumonia. (Removed from the peritoneum.)	3. Ditto ditto. (Removed from the pleura.)	4. Metro-peritonitis. (Abdominal fluid.)	5. Metro-peritonitis. (Abdominal fluid.)	6. Metro-peritonitis. (Abdominal fluid.)	7. Metro-peritonitis. (Abdominal fluid.)	8. Peritonitis metritis. (Abdominal fluid.	9. Peritonitis in a child eight years of age.
Water	963.39	909.83	936.718	909.79	902.70	905.74	966.10	941.27	980.00
Solid matters	36.61	90.17	63.282	90.21	97.30	94.26	33.90	58.73	20.00
Albumen	12.82	48.95	31.746	48.17	36.82	32.46	...	25.21	6.49
Albuminate of soda	7.13	...	...	...	...	...	18.72	...	...
Fat	0.34	14.105	25.503	1.97	6.20	6.91	1.35	2.32	...
Extractive matters	7.70			20.96	20.32	20.05	6.12	20.38	4.74
Pyin, or a substance analogous to it, precipitated by acetic acid	...	8.96	...	9.90	12.41	10.42	...	4.37	2.45
Salts	8.58	8.88	7.110	9.00	8.83	9.38	8.73	7.93	6.32
Hydrochlorate of ammonia	...	9.30	...	...	...	...	...	...	...
Pus and exudation corpuscles	...	...	...	...	13.81	14.67	...	...	...
Free lactic acid	...	1.05	1.610	...	...	1.50	...	...	...

ARTICLE III.

OF THE CUTANEOUS PERSPIRATION.

Sect. I.—Of the Cutaneous Perspiration in Health.

This exhalation has been made the subject of investigation by various chemists, viz., Thenard, Chevreuil, Berzelius, and Anselmino. Simon has likewise examined it with great attention. His researches, albeit qualitative, nevertheless permit of our laying down the following propositions, relative to the composition of the cutaneous exhalation in health.

It contains:

1. Certain substances soluble in æther; these are merely traces of fatty matter, among which is found a small quantity of butyric acid.
2. Substances soluble in alcohol; these are alcoholic extracts, free lactic and acetic acids, chloride of sodium, lactates and acetates of soda and potash, lactate or hydrochlorate of ammonia.
3. Substances soluble in water: viz., an aqueous extract, phosphate of lime, and, occasionally, an alkaline sulphate.
4. Substances insoluble in water, such as epithelial scales and, after the removal of the free acid by alcohol, phosphate of lime and a little peroxide of iron.

Previous to the investigations of Simon, Berzelius had already pointed out the existence of these same principles in healthy perspiration; but, until lately, it was to Anselmino that we were indebted for the most accurate researches published respecting this fluid.

In 100 parts of the solid residuum of the cutaneous exhalation, Anselmino found the following:

Substances insoluble in water and alcohol, especially salts of lime	2.0
Aqueous extract and sulphates	21.0
Ætherial extract, with chloride of potassium and sodium	48.0
Alcoholic extract, acetic acid, acetates, and lactates .	29.0

These numbers can only be regarded as approximative.

In 1000 parts of perspiration, Anselmino found :

	1.	2.
Water	995.000	987.500
Epidermis and salts of lime	0.100	0.250
Watery extract and sulphates	1.050	2.625
Ætherial extract, chloride of potassium and sodium	2.400	6.000
Alcoholic extract, acetates, lactates, and free acetic acid	1.450	3.625

In 100 parts of dried perspiration, there were 22.9 of fixed salts, consisting of carbonates, sulphates, and phosphates of soda and of potash, chloride of sodium, phosphate and carbonate of lime, together with traces of peroxide of iron.

The odour of the perspiration depends upon its admixture with the secretions of the sebaceous glands.

It is to M. Favre (*Arch. gen. de Méd.* July 1853) that we are indebted for the most recent, complete, and accurate researches relative to the composition of the cutaneous exhalation in health.

In order to obtain a sufficient quantity of this fluid, M. Favre adopted the use of a special apparatus, a description of which we shall quote.

" The apparatus destined to collect the perspiration, and to " cause it to flow into a flask as fast as formed, consisted of a " species of case made of well tinned iron, the sides of which " were inclined, so as to form the trunk of an inverted pyramid. " This case was upwards of two yards long,* and 0.5 of a yard " in breadth; the sides, inclined at an angle of 45 degrees, " rose about one inch from the base.

" This species of bath was placed upon a low table, made for " the purpose, and having a slight inclination. The head of " the individual corresponded to the summit of the inclined " plane, and the feet to the lower extremity.

" As at least an hour and a half was necessary for the pro- " duction of a sufficient quantity of perspiration, that part of " the bath upon which the head of the individual to be expe-

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* *Strictly speaking, seventy-eight inches in length.*

" rimented upon rested, was hollowed out, so as to avoid, as " much as possible, all unnecessary fatigue or annoyance.

" It will readily be understood, that owing to the inclined " position of the individual, the perspiration would gradually " trickle down to the lower portion of the bath and accumulate " there, had not an outlet been contrived for its removal. For " this purpose, a gutter conducted the fluid towards an aper- " ture, in which was soldered a small tube fastened into the " neck of a flask. By this method, the greater portion of the " perspiration formed during the operation could, without dif- " ficulty, be collected.

"The apparatus just described was placed in the centre of a " stove heated by a jet of steam. It was necessary, therefore, " to avoid the admixture with the perspiration, of water " derived from the steam condensing upon the metal of the " apparatus, or falling in drops from the roof of the stove. To " avoid this, the apparatus was protected and completely " covered by a sheet, with the exception of that part upon " which the head reclined ; and as the individual required to " be in contact with the metal only, this sheet was prevented " from touching either his body, or the sides of the bath, by " means of half circles of metal."

The perspiration thus collected, was submitted to a series of most complicated chemical operations, which we cannot here describe.

The following are the results of an analysis made by M. Favre upon upwards of ten quarts of the cutaneous perspiration. It may be considered as representing the mean composition of this fluid in health, in the individual experimented upon.

			In the entire quantity.	In 1000 grammes.
1st portion	Soluble in water.	Chloride of sodium	grammes. 31.327	gr. 22.305
		Chloride of potassium .	3.412	2.437
		Alkaline sulphates . .	0.161	0.115
		Alkaline phosphate . .	traces	traces
		Alkaline albuminates .	0.070	0.050
	Soluble in acidulated water.	Earthy alkaline phosphates	traces	traces

	Fragments of epidermis	traces	traces
2nd portion	Alkaline lactates	4.440	3.171
	Alkaline sudorates	21.873	15.623
3rd portion	Urea	0.599	0.428
	Fatty matters	0.191	0.137
	Water	1,3938.027	9,955.783

M. Favre remarks, that he has found urea in the perspiration, but not the ammoniacal salts pointed out by other authorities; which would seem to indicate, that in the chemical operations of the latter, the urea might have been converted into carbonate of ammonia, this salt, as is well known, being easily produced under the influence of fermentation induced by traces of nitrogenized matters.

M. Favre has likewise published another table, which we shall shortly quote. It indicates the result of various analyses made upon perspiration, collected on different days from the same individual.

In these analyses, M. Favre was satisfied with determining the substances that were insoluble and soluble in pure alcohol, these being represented by the sudorates and alkaline lactates. The alkalinity of these latter salts, when incinerated, was determined by considering it as entirely due to the presence of soda. The sum total of the figures included within the same brackets, represent the aggregate of the matters soluble in pure alcohol, as ascertained by experiment.

The figures which correspond to the column marked VIII, are borrowed from the analysis quoted above.

	I.	II.	III.	IV.	V.	VI.	VII. From two experiments.	VIII. From six experiments.
	Gr.	Gr.	Gr.	Gr.	Gr.	Gr.	Gr.	Gr.
Water	2253.860	2234.124	1521.166	5776.625	2139.145	2557.888	4402.266	13938.027
Alkali	0.680	0.702	0.650	1.708	0.720	0.696	1.004	4.183
Lactate and sudoric acid . .	3.661	3.371	5.183	9.202	3.310	3.938	5.646	22.920
Substances insoluble in alcohol, sea salt, etc.	6.799	6.803	6.803	17.465	6.825	7.478	10.084	34.803
Total . . .	2265.000	2245.000	1530.000	5805.000	2150.000	2570.000	4419.000	14000.000
In 100 parts of perspiration.								
Water	99.509	99.516	99.422	99.509	99.496	99.529	99.628	99.558
Alkaline lactates and sudorates .	0.191	0.181	0.251	0.189	0.187	0.180	0.153	0.193
Substances insoluble in alcohol .	0.300	0.303	0.327	0.302	0.317	0.291	0.219	0.249
Total . . .	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
In 100 parts of the solid matter.								
Alkaline lactates and sudorates .	38.900	37.397	43.445	38.493	37.104	38.216	41.488	43.734
Substances insoluble in alcohol .	61.100	62.603	56.555	61.507	62.896	61.784	58.512	56.266
Total . . .	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Proportion of alkali (soda) contained in 100 parts of a mixture of lactates and sudorates.								
Soda	15.665	17.235	16.958	15.655	17.866	15.010	15.098	15.492

From this table it would appear, that the perspiration collected on different days from the same individual, if not absolutely identical in point of composition, presents at least but slight variations.

M. Favre observes, that of the entire amount of fluid furnished by the same individual during a single experiment, the first third was always acid; the second, neutral or alkaline; and the third, always alkaline.

The following table shews the results obtained from a certain amount of the cutaneous exhalation, collected on two different occasions and mixed.

The sum total of the figures comprised within the same brackets, represents the aggregate of matters soluble in alcohol, as ascertained by experiment.

The alkalinity of the fluid is regarded as entirely due to the presence of soda.

	1st half hour. Gr.	2nd half hour. Gr.	3rd half hour. Gr.	A* Gr.
Water	1053.419	1682.091	1666.756	4402.266
Alkali	0.200	0.481	0.323	1.004
Lactic and sudoric acid .	1.654	2.422	1.570	5.646
Substances insoluble in alcohol, sea salt, etc. . .	1.727	5.006	3.351	10.084
Total . .	1057.000	1690.000	1672.000	4419.000
In 100 *parts of perspiration.*				
Water	99.662	99.553	99.687	99.628
Alkaline lactates and sudorates	0.175	0.171	0.113	0.153
Substances insoluble in alcohol	0.163	0.296	0.200	0.219
Total . .	100.000	100.000	100.000	100.000
Composition referred to 100 *parts of the solid matters.*				
Alkaline lactates and sudorates	51.777	36.595	36.094	41.488
Substances insoluble in alcohol	48.225	63.405	63.906	58.512
Total . .	100.000	100.000	100.000	100.000
Proportion of alkali (soda) contained in 100 *parts of a mixture of lactates and sudorates.*				
Alkali (soda)	11.272	16.569	17.063	15.098

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* The figures inscribed in this column A, represent the sum total of those comprised in the previous three columns; they have been already quoted in column VII of the preceding table.

At the close of his memoir, M. Favre makes the following observations.

"The results thus obtained appear to warrant certain conclusions, which are these.

"1. The amount of perspiration collected during the second half hour, is the same as during the third; whilst the proportion collected in the first half hour, is, relatively speaking, smaller: an occurrence by no means surprising.

"2. The ratio between the quantity of water and that of the solid matters does not sensibly vary at these different periods.

"3. The quantity of mineral salts contained in the second portion collected, appears to be a *maximum*. The proportion of salts to the organic acids contained in the third portion collected, is a *minimum*.

"4. On examining the relative proportion of the salts, of the organic acids, and of the salts of the mineral acids, contained in the same weight of solid matter, we find, that in the first portion, the proportion of salts of the organic acids predominates considerably over that of the mineral salts; the proportion is the same for the two remaining portions collected.

"5. The proportion of true alkali contained in a similar quantity of the salts of the organic acids, is decidedly smaller in the first than in the succeeding portions; this indicates a larger amount of sudoric than of lactic acid; the equivalent of sudoric acid being about double that of lactic acid.

"On comparing the composition of the cutaneous perspiration with that of the urinary secretion, we find, that the predominating mineral substance is, in both cases, sea salt. This is no longer the case as regards the sulphates, which are much more abundant in the urine than in the perspiration, where traces only of their existence have been detected. The same may likewise be said of the phosphates. These conclusions will appear warranted from the following comparison, made between equal quantities of the urine and perspiration of the same individual, simultaneously collected. The amount of urine passed in the twenty-four hours varied from twenty-eight to fifty ounces.

	In ten quarts of perspiration. Gr.*	In ten quarts of urine. Gr.
Chlorides	34.639	57.018
Sulphates	0.160	21.769
Phosphates	traces	5.381

"We deem it not uninteresting to follow out this comparison between the perspiration and the urine, with reference to the alkaline salts of the organic acids.

"The subjoined numbers afford the elements of such a comparison.

	In ten quarts of perspiration. Gr.	In ten quarts of urine. Gr.
Alkalies (represented by soda) .	4.183	2.494
Organic matters	22.920	139.650

"The 139 gr. 650 of organic matters contained in the urine, comprise neither the urea nor the uric acid.

"The ratio between the mineral salts and the alkali combined with organic acids is, in the perspiration, :: 34.80 : 4.18, or, :: 100 : 12.01, whilst in the urine it is, :: 84.17 : 2.49, or, :: 100 : 2.95.

"It is evident, that comparisons of this kind can only be rendered available, by comparing the relationship existing between the different constituents of the urine, with those which exist between the same constituents of the perspiration. We shall not, therefore, lay stress upon any other results than such as may be derived from a comparison thus instituted.

"The preponderance of chloride of sodium in the perspiration appears clearly demonstrated, together with the absence of sulphates and phosphates, as compared with the urine.

"On summing up the reflections suggested by the comparative composition of the urine and of the perspiration, it may be stated, that the mineral salts are not indiscriminately eliminated by the different emunctories of the economy.†

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* *Grammes.*

† "It would undoubtedly be interesting to compare the quantity of solid material eliminated by the skin, under ordinary circumstances, with that of the solid matters afforded by the urine in a similar space of

"As for the organic matters of the perspiration, some of them may likewise be found in the urine; one, however, appears peculiar to the former; all these substances seem highly oxygenized, and to have already undergone in the circulation a considerable degree of combustion, similar, in a measure, to that of the organic matters eliminated by the kidneys.

"It is needless to speak of the interest which would attach to a study of the composition of the cutaneous perspiration in different individuals, both healthy and diseased. We have lately, in conjunction with M. Andral, undertaken some researches in this direction. To these, however, we cannot at present refer.

"*Conclusions.*—To sum up, then, we deem it possible to draw the following conclusions from the facts just stated.

"1. The matters of the perspiration are almost entirely soluble in pure water.

"2. The preponderating mineral ingredient of the perspiration is chloride of sodium, as had been already stated.

"3. The proportion of alkaline sulphates is extremely small; that of the alkaline, or earthy alkaline phosphates, is almost *nil.*

"4. Analysis clearly demonstrates the existence of lactic acid, in the form of alkaline lactates, as had been stated, but not completely proved, by elementary analysis.

"5. The experiments related in this memoir indicate the discovery, in the perspiration, of a new nitrogen acid, *sudoric acid,* which is found in combination with alkalies. The formula of this acid resembles, to a certain extent, that of uric acid, which, as we have already stated, does not exist in the perspiration.

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time, such, for instance, as twenty-four hours, in order to ascertain how far these two secreting functions are complementary for the expulsion of a certain quantity of solid matters; unfortunately we know of no means by which to render comparable, the deductions afforded by forced perspirations, with those furnished by ordinary natural sweating."

"6. It would appear, moreover, from these researches, that urea is found in this fluid; its presence there had not been previously recognized.

"7. The proportion of fatty and albuminous matters, in the state of alkaline albuminates, is extremely small.

"8. The proportion of potash, as compared with that of soda, is, relatively speaking, greater in the salts of the organic acids than in the mineral salts contained in the perspiration.

"9. The perspiration collected from the same individual, on different occasions, presented but slight variations as regards composition, provided that the amount of fluid removed was about the same on each occasion.

"10. When the perspiration obtained by one experiment is divided into several portions, corresponding with equal divisions of the time during which such experiment has lasted, we find certain differences in the relative proportions both of the mineral salts and of the salts of the organic acids, the first of these being most abundant during the latter period of the experiment.

"11. The proportion of water to the aggregate of solid matters does not perceptibly vary during the course of a single experiment."

SECT. II.—Of the Perspiration in Disease.

M. Favre is at present engaged, in conjunction with M. Andral, in investigating the composition of the cutaneous exhalation in disease. When these researches shall have been published, we may, perhaps, be enabled to discuss this subject, and to determine the value of chemical analysis in relation to the morbid conditions of the perspiration.

In the mean time, however, we deem it right to say a few words concerning the investigations that have hitherto been made in this direction.

Piutti (of Elgersburg) has made three analyses of perspiration, collected under the following circumstances.

	A man, 36 years of age, suffering from atonic gout for 12 years. 1.	A man, 54 years of age, suffering from gout for 3 months. 2.	A girl, 22 years of age, paraplegic. 3.
Specific gravity of the perspiration	1003.5	1004.0	1003.0
Water	995.5	993.0	994.6
Chloride of sodium	3.0	4.0	3.3
Phosphate of ammonia	0.5	0.8	1.1
Acetate of ammonia	0.5	0.6	0.5
Hydrosulphate of ammonia	traces	...	traces
Extractive matters	0.5	1.6	0.5

Simon has, likewise, published a lengthened dissertation relative to the perspiration in disease, but he has given no positive results.

We shall here quote a few of his observations.

The perspiration, sometimes, has a peculiar odour. In persons affected with itch it often resembles that of must; in syphilitic patients it has a sweetish smell; the perspiration of rheumatic and gouty individuals has an acid smell; in typhoid fever and scurvy it has a putrid odour; and in jaundice it somewhat resembles that of musk. The odour of the perspiration in scrofulous persons is similar to that of sour butter, and that of the perspiration in intermittent fever resembles the smell of bread recently baked.

We have ourselves never perceived anything of the kind, and such assertions would seem, either to refer to particular cases that have been generalized, or to be the result of the individual perceptions of the observer.

According to Simon, the quantity of free acid (lactic acid) is always increased in the perspiration of individuals suffering from gout or rheumatism. Sometimes acetic acid is combined with lactic acid in such cases.

Prout discovered acetic acid in the perspiration of a patient suffering from hectic fever; and in that of another, after an attack of acute articular rheumatism.

According to Stark, the lactic acid of the perspiration is increased in scrofula, in rachitis, and in certain cutaneous diseases.

According to Anselmino, the same acid predominates in females when incarcerated.

The ammonia of the perspiration augments in some instances.

Gout is said by Anselmino to produce this result.

Behrend asserts the same of typhus and typhoid fever. It occurs also, according to Nauché, in nervous diseases.

Lastly, Anselmino states that in certain cases of gout the salts are increased.

ACCIDENTAL MATTERS FOUND IN THE PERSPIRATION.

Albumen.—This principle was discovered by Anselmino, in a critical perspiration following an attack of acute rheumatism. Stark states, that it may be likewise found in typhoid and hectic fevers, and in the sweats which precede death.

2. *Blood.*—Blood is sometimes met with in the perspiration. Voigtel noticed a bloody sweat upon the arm of a young man after violent muscular exertion. In scurvy, simple typhus, and typhus icterodes, it is stated, that bloody sweats have sometimes been observed.

Bilin and biliphœin have been found in the perspiration of individuals suffering from jaundice. According to Behrend, in the fever which he designates putrid bilious fever (typhoid fever with bilious symptoms, or bilious remittent), biliary pigment is found in the perspiration.

4. Several observers have discovered a *blue colouring matter* in the perspiration: Landerer, in that from the axilla; Bleifuss, in that of the foot; Michel, in an hysterical female, and in a hypochondrical male; Billard, in the perspiration from the upper part of the carpus of a young girl.

5. *Uric acid.*—Stark found uric acid in the perspiration of rheumatic patients; and Wolff, urate of soda in that of gouty individuals.

Fat has been found in the perspiration of those labouring under hectic fever.

Matters entirely foreign to the organism may sometimes be met with in the perspiration. Landerer discovered sulphate of quinine in that of patients who were taking large doses of this medicine. Sulphur, mercury, iodine, iodide of potassium, assafœtida, garlic, saffron, olive oil, rhubarb, indigo, Prussian blue, and copper, have likewise been detected (Stark).

CHAPTER V.

CHANGES OCCURRING IN THE SOLID PARTS OF THE ORGANISM.

IN this chapter we shall examine the normal composition of some of the tissues, and conclude with a short exposition of certain pathological results, which, although still very incomplete, are nevertheless all that science possesses relative to the subject in question.

ARTICLE I.

OF BONE.

The normal composition of bone is a point of considerable interest. It serves, in fact, as a starting point for the study of those numerous changes which may occur in this tissue.

According to Berzelius, the following is the composition of bone, in the human subject:

Phosphate of lime	51.04
Fluoride of calcium	2.00
Carbonate of lime	11.30
Phosphate of magnesia	1.16
Soda, with a little chloride of sodium	1.20
Cartilage	37.17
Vessels	1.13

Thomson has given the following analysis of a human femur:

	1.	2.
Phosphate of lime	43.67	51.12
Carbonate of lime	14.00	9.77
Magnesia	0.49	0.63
Soda	2.00	0.59
Potash	0.06	traces
Cartilage	39.12	35.93

Marchand has given the following analysis of the compact substance of the femur, in a man thirty years of age :

Basic phosphate of lime	52.26
Fluoride of calcium	1.00
Carbonate of lime	10.21
Phosphate of magnesia	1.05
Soda	0.92
Chloride of sodium	0.25
Cartilage insoluble in hydrochloric acid	27.23
Cartilage soluble in ditto	5.02
Vessels	1.01
Peroxide of iron and manganese, and loss	1.05

Valentin has published the four following analyses :

	1. Tibia of a man 38 years of age.	2. Medullary portion of the same bone.	3. External condyle of the left femur of a girl.	4. Head of the left tibia of the same.
Basic phosphate of lime	52.930	49.019	37.012	41.774
Carbonate of lime	7.666	7.660	5.038	7.109
Phosphate of magnesia	0.254	1.542	0.874	0.874
Chloride of sodium	0.911	0.441	0.654	1.677
Carbonate of soda	0.204	0.076	1.331	
Cartilage, vessels, etc.	38.020	41.160	55.180	48.560

Lehmann has also published some important analyses of human bone.

	A man, 40 years of age.						A man, 44 years of age.		
	Humerus.	Radius.	Ulna.	Femur.	Fibula.	Tibia.	Femr.	Tibia.	Fibula
Phosphate of lime and fluoride of calcium	56.61	53.25	53.98	58.93	52.99	53.12	52.67	52.93	52.04
Carbonate of lime	9.20	9.76	9.51	9.28	9.33	9.35	10.03	9.88	10.13
Phosphate of magnesia	1.08	1.06	1.07	1.09	1.06	1.07	0.93	0.91	0.89
Chloride of sodium	0.37	0.36	0.40	0.40	0.37	0.39	0.34	0.31	0.39
Soda	1.35	1.36	0.98	1.04	1.07	0.99	1.07	1.09	1.12
Organic matters	51.52	33.76	33.23	28.61	34.13	44.10	34.15	33.94	34.51

The most complete analyses of human bone are due to Von Bibra. They will be found in the following table.

		Femur.	Tibia.	Humerus.	Ulna.	Radius.	Ribs.	Clavicles.	Vertebræ.	Fibula.	Scapula.	Metacarpus.	Bones of the cranium.
A male fœtus, at the 6th or 7th month.	Phosphate of lime, with a little fluoride of calcium	53.46	53.46	53.15									
	Carbonate of lime	3.06	3.10	3.05									
	Phosphate of magnesia	2.10	2.00	1.96									
	Salts, insoluble in water	1.00	1.07	1.02									
	Cartilage	40.38	40.37	40.82									
	Fat	traces	traces	traces									
A female fœtus, at the 7th month.	Phosphate of lime, etc.	..	..	..	57.63	57.67	..	56.95	..	..	57.13		
	Carbonate of lime	..	..	..	5.80	5.89	..	5.75	..	..	5.99		
	Phosphate of magnesia	..	..	..	1.10	0.99	..	1.67	..	..	1.12		
	Salts, insoluble in water	..	..	..	0.60	0.67	..	0.73	..	..	0.62		
	Cartilage	..	..	..	84.78	34.08	..	34.54	..	..	34.32		
	Fat	..	..	..	0.63	0.50	..	0.96	..	..	0.82		
An infant, 2 months old.	Phosphate of lime, etc.	..	57.54	..	56.35								
	Carbonate of lime	..	6.02	..	6.07								
	Phosphate of magnesia	..	1.03	..	1.00								
	Salts, insoluble in water	..	0.73	..	1.65								
	Cartilage	..	33.86	..	34.92								
	Fat	..	0.82	..	1.01								
An infant, 9 months old.	Phosphate of lime, etc.	48.11	48.53	50.15	48.06	45.38	42.32	..	..	..	42.61		
	Carbonate of lime	6.12	5.79	6.13	6.20	6.11	5.60	..	..	..	5.08		
	Phosphate of magnesia	0.97	1.00	1.00	1.01	0.95	0.89	..	..	..	0.92		
	Salts, insoluble in water	1.23	1.24	1.30	1.24	1.07	1.09	..	..	..	1.10		
	Cartilage	47.71	41.50	39.54	41.70	45.65	48.55	..	..	..	48.36		
	Fat	1.86	1.92	1.89	1.79	1.83	1.15	..	..	..	1.93		
A female child, 5 months old.	Phosphate of lime	59.06	59.75										
	Carbonate of lime	5.91	6.00										
	Phosphate of magnesia	1.24	1.34										
	Salts, insoluble in water	0.69	0.63										
	Cartilage	31.28	31.34										
	Fat	0.92	0.95										
A girl, 19 years of age.	Phosphate of lime	54.78	..	54.84									
	Carbonate of lime	10.90	..	10.82									
	Phosphate of magnesia	1.34	..	1.26									
	Salts, insoluble in water	0.83	..	0.79									
	Cartilage	31.15	..	31.37									
	Fat	1.00	..	0.92									

		Femur.	Tibia.	Humerus.	Ulna.	Radius.	Ribs.	Clavicles.	Vertebræ.	Fibula.	Scapula.	Metacarpus.	Bones of the cranium.
A woman, 25 years of age.	Phosphate of lime, etc.	57.12	57.18	58.03	57.52	57.38	52.91	56.35	44.28	57.39	54.76	57.77	57.66
	Carbonate of lime	8.92	8.93	9.04	8.97	8.95	8.66	8.88	8.00	8.92	8.58	8.92	8.75
	Phosphate of magnesia	1.70	1.70	1.59	1.71	1.72	1.40	1.69	1.44	1.63	1.53	1.58	1.69
	Salts, insoluble in water	0.60	0.61	0.59	0.67	0.63	0.60	0.59	0.53	0.60	0.51	0.61	0.63
	Cartilage	29.54	29.58	29.66	29.14	29.43	33.06	30.66	43.44	29.49	32.90	29.23	29.87
	Fat	1.82	2.00	1.09	1.99	1.89	2.37	1.83	2.31	1.97	1.73	1.89	1.40
A man, 25 years of age.	Phosphate of lime, etc.	59.63	58.95	59.87	59.30	..	56.66	..	..	..	..	..	38.43
	Carbonate of lime	7.33	7.08	7.76	7.35	..	6.64	..	..	..	..	..	8.00
	Phosphate of magnesia	1.32	1.30	1.09	1.35	..	1.07	..	..	..	..	..	1.40
	Salts, insoluble in water	0.69	1.70	0.72	0.73	..	0.62	..	..	..	..	..	0.90
	Cartilage	29.70	30.42	20.28	29.08	..	33.97	..	..	..	..	..	29.92
	Fat	1.53	1.55	1.28	1.29	..	2.04	..	..	..	..	..	1.35
A man, 58 years of age.		Compact substance of femur.											
	Phosphate of lime, etc.	58.23											
	Carbonate of lime	8.35											
	Phosphate of magnesia	1.03											
	Salts, insoluble in water	0.92											
	Cartilage	31.47											
		Spongy substance of ditto.											
	Phosphate of lime, etc.	42.82											
	Carbonate of lime	19.37											
	Phosphate of magnesia	1.00											
	Salts, insoluble in water	0.99											
	Cartilage	35.82											
A woman, 62 years of age.	Phosphate of lime, etc.	63.17											
	Carbonate of lime	4.46											
	Phosphate of magnesia	1.29											
	Salts, insoluble in water	0.90											
	Cartilage	28.03											
	Fat	2.15											
A woman, 76 years of age.	Phosphate of lime, etc.	57.36											
	Carbonate of lime	7.48											
	Phosphate of magnesia	1.10											
	Salts, insoluble in water	0.97											
	Cartilage	33.16											
	Fat	0.93											

The mean composition of human bone, as deduced from fifty-four analyses made by different experimenters, may be represented as follows:

Phosphate of lime	54.07	100.00
Phosphate of magnesia	1.20	
Carbonate of lime	7.40	
Fat	1.35	
Soda and salts of soda	0.93	
Cartilage	35.05	

The chemical composition of healthy bone being perfectly established, we shall proceed to consider the modifications which may occur in disease.

SECT. I.—Osteo-Malacia.

M. Beylard, author of a thesis on rachitis, fragilitas ossium, and osteo-malacia, has treated of the analysis of diseased bone. He knew but little, however, of the works of German authors, and had probably not consulted the excellent treatise of Simon; for the researches of Rees are the only ones of which he makes mention.

According to Rees, the different bones of the skeleton do not contain in health the same proportion of calcareous salts and organic matters. It is, consequently, difficult to determine with accuracy, the changes which take place in softened bone.

The following are, according to this author, the comparative results of an analysis of a fibula, a rib, and a vertebra, taken from an individual suffering from osteo-malacia.

	Healthy bone.		Softened bone.	
	Earthy matters.	Organic matters.	Earthy matters.	Organic matters.
Fibula	60.02	39.98	32.50	67.50
Ribs	54.49	42.51	30.00	70.00
Vertebræ	57.42	42.58	26.13	73.87

The two following analyses of softened bone are due, the one to Bostock, the other to Prœsch.

	Bostock.	Prœsch.	
	Dorsal vertebræ.	Dorsal vertebræ.	Ribs.
Cartilage	79.95	74.64	49.77
Phosphate of lime	13.60	13.25	33.66
Phosphate of magnesia	0.82	...	...
Carbonate of lime	1.13	5.55	4.60
Sulphate of lime and phosphate of soda	4.70	0.90	0.40
Fat	...	5.26	11.63

Solly has given the following analysis of the medullary membrane and osseous substance of an individual affected with osteo-malacia.

	Medullary matter.	Osseous matter.
Animal matter	24.78	18.75
Calcareous phosphates	1.83	29.17
Water	73.39	52.08

M. Barruel, jun., found 18 parts of earthy salts and 82 of organic matter, in 100 parts of bone affected with osteo-malacia. The bones of the fore-arm, which were less softened, afforded 29 of salts and 71 of organized matter, per cent.

Dr. Buisson, in a thesis published in 1851, gives the following analysis of the inferior extremity of the femur of a female suffering from osteo-malacia. She was thirty-eight years of age, and her bones had been fractured more than eighty times.

Cartilage	54.3750
Phosphates	39.1625
Carbonates	6.4725

These analyses, says the author, prove that the same results are obtained, whether the bones be softer or more fragile than in health. In all cases, there is a considerable decrease of the earthy matter, and a proportionate increase of the organic matter.

The subjoined analyses are quoted from the treatise of Simon:

Boguer has given the following analyses of four bones belonging to a man affected with osteo-malacia.

	Scapula.	Radius.	Femur.	Patella.
Phosphate of lime . .	26.92	28.11	23.50	23.23
Carbonate of lime . .	0.98	1.07	0.97	0.94
Phosphate of magnesia .	5.40	6.35	5.07	5.03
Cartilage and vessels .	65.85	63.42	69.77	70.60
Soda, iron, and loss . .	0.85	1.05	0.69	0.64

Ragsky gives the following analysis of a rib similarly affected:

Phosphate of lime and magnesia	17.48
Other salts	6.32
Cartilage, vessels, and fat	76.20

Lehmann, after removing all the adipose matter, obtained the following results in three cases of osteo-malacia:

Phosphate of lime . . .	36.863	31.718	35.871
Other salts	4.968	7.913	5.684
Cartilage	58.169	60.369	58.445

Lehmann has, likewise, given the results of analysis in two individuals forty years of age, suffering from osteo-malacia.

	1.		2.	
	Femur.	Rib.	Femur.	Rib.
Phosphate of lime . .	17.56	21.02	18.83	19.14
Carbonate of lime . .	3.04	3.27	3.83	4.08
Phosphate of magnesia .	0.23	0.44	0.54	0.60
Soluble salts	0.37	0.63	0.43	0.41
Cartilage	48.83	50.48	41.54	42.43
Fat	29.18	23.13	34.15	32.65

Von Bibra has given three analyses of bone in cases of osteomalacia. The first refers to the tibia of a woman, seventy-five years of age; the second to the femur of a woman, eighty-three years of age; and the third to the femur of a man, sixty years of age.

	1.	2.	3.
Phosphate of lime, with a little fluoride of calcium . .	55.01	46.79	53.25
Carbonate of lime	4.04	6.37	7.49
Phosphate of magnesia . .	2.01	1.20	1.22
Salts	0.31	1.37	1.35
Cartilage	29.17	30.99	32.54
Fat	8.56	13.28	4.15

The following analysis of the bones of a child affected with osteo-malacia, was made by Marchand :

	Vertebræ.	Radius.	Femur.	Sternum.
Phosphate of lime . . .	12.56	15.11	14.78	21.35
Phosphate of magnesia . .	0.92	0.78	0.80	0.72
Carbonate of lime . . .	3.20	3.15	3 00	3.70
Sulphate of lime and of soda .	0.98	1.00	1.02	1.68
Fluoride of calcium, chloride of sodium, iron, and loss .	1.00	1.20	1.00	2.01
Cartilage	75.22	71.26	72.00	61.20
Fat	6.12	7.50	7.20	9.34

These results are all identical: they enable us to state generally, the nature of those changes which the bones undergo, in the disease termed osteo-malacia. They are as follows:

a. Considerable decrease in the proportion of phosphate of lime;

b. Proportionate increase of the cartilaginous matter;

c. Increased proportion of fatty matter: this increase may sometimes be very considerable.

SECT. II.—Rachitis.

MM. Pelouze and Fremy have given two complete analyses of rickety bone, in their *Treatise on Chemistry.* In some bones, the decrease of calcareous matters was even greater than in individuals suffering from osteo-malacia.

The following are the analyses made by the above chemists:

	Dorsal vertebræ.	Dorsal vertebræ.	Ribs.	Cranium.	Radius.	Femur.	Patella.
Cartilage . .	79.75	74.64	49.77	65.85	63.42	69.77	70.60
Phosphate of lime .	13.60	13.25	33.60	26.92	28.11	23.50	23.23
„ of magnesia	0.82	...	...	0.98	1.07	0.97	0.94
Carbonate of lime .	1.13	5.95	4.60	5.40	6.35	5.07	5.03
Sulphates of soda and lime . .	4.60	0.90	0.40	...	...	...	...
Fatty matter .	...	5.26	...	11.63	...	...	...
Soda, iron, and manganese . .	...	...	...	0.85	1.05	0.69	0.64

The following analysis of the bones of a rickety child is given by Marchand :

	Vertebræ.	Radius.	Femur.	Sternum.
Cartilage	75.22	71.26	72.20	61.20
Fat	6.12	7.50	7.20	9.34
Phosphate of lime	12.56	15.11	14.78	21.35
Phosphate of magnesia	0.92	0.78	0.80	0.72
Carbonate of lime	3.20	3.15	3.00	3.70
Sulphates of soda and lime	0.98	1.00	1.02	1.68
Fluoride of calcium, sea salt, iron, loss	1.00	1.20	1.00	2.01

Here, again, it is the same constituent which undergoes a modification. The calcareous salts, and especially the phosphate of lime, are greatly diminished in quantity, while the proportion between the organic and inorganic matters is precisely the inverse of what it is in health.

Lehmann, having analyzed the tissues of three rickety children, obtained the following results:

	1.	2.	3.
Phosphate of lime	32.04	26.94	28.13
Carbonate of lime	4.01	4.88	3.75
Phosphate of magnesia	0.98	0.81	0.87
Chloride of sodium	0.21	0.27	0.28
Soda	0.54	0.81	0.73
Cartilage	54.14	60.14	58.77
Fat	5.84	6.22	6.94

Ragzky gives the following analysis of the scapula and humerus of a rickety child.

Phosphate of lime and magnesia	15.60
Carbonate of lime	2.66
Soluble salts	0.62
Cartilage, vessels, and fat	81.12

Von Bibra analyzed the ulna of a rickety child six years of age, thus:

Phosphate of lime, with a little fluoride of calcium	47.83
Carbonate of lime	7.42
Phosphate of magnesia	1.23
Salts	1.82
Cartilage	35.61
Fat	6.09

The analysis, therefore, of bones affected with rachitis, affords the following pathological results :

a. Decrease of the phosphate of lime ;
b. Increase of the cartilages ;
c. Increase of the adipose matter.

These modifications require to be taken into serious consideration in the treatment of rachitis.

SECT. III.—Caries.

We are indebted to Valentin and Von Bibra for some important analyses of carious bone, which we here subjoin.

Analyses of Valentin.

	Tibia of a man, 38 years of age.	Vertebræ of a man, 20 years of age.	External condyle of the femur of a girl.	Head of the tibia of the same.
Phosphate of lime . .	34.383	33.914	39.393	45.451
Carbonate of lime . .	6.636	7.602	4.620	5.683
Phosphate of magnesia .	1.182	0.389	0.520	1.180
Chloride of sodium .	1.919	3.157	0.424	1.620
Carbonate of soda . .		0.118	0.647	0.446
Organic matters . .	55.880	54.830	54.396	45.620

Analyses of Von Bibra.

	Carious bones of a man's hand.			Femur of a man.						
	Metacarpal bone.	Articular extremity.	Phalanx.	Diseased part.	The entire bone.	Palate bone of a woman, 40 years of age.	Tarsus of a man, 45 years of age.	Nasal bone of a girl, 15 years of age.	Lumbar vertebra of a woman, 40 years of age.	Tibia of a man, 25 years of age.
Phosphate of lime, with a little fluoride of calcium	49.77	31.36	49.36	51.53	54.98	45.14	39.22	45.77	44.05	47.79
Carbonate of lime ..	7.24	4.07	8.08	5.44	5.97	5.03	6.87	3.77	3.45	6.44
Phosphate of magnesia	1.11	0.83	0.98	3.43	3.70	2.40	0.50	1.45	1.02	1.30
Salts..............	0.30	0.30	0.40	0.91	0.89	0.82	2.10	1.10	1·70	2.00
Cartilage..........	37.97	59.36	37.47	35.69	31.44	42.34	29.23	38.62	41.42	28.57
Fat	3.61	4.08	3.71	3.00	3.02	4.27	22.09	9.29	8.36	13.60

An examination of the above analyses enables us to draw some conclusions, which may prove serviceable in the treatment of caries. They shew that in this disease there is :—

1. Marked decrease in the proportion of phosphate of lime;
2. An occasional slight increase of the carbonate of lime;
3. No change in the phosphate of magnesia and soluble salts;
4. Normal proportion of cartilage, the texture of which is altered;
5. A frequent and considerable increase of adipose matter.

SECT. IV.—Necrosis.

Von Bibra has analyzed the necrosed phalanges of a man, between forty and fifty years of age, with the following results:

Phosphate of lime and fluoride of calcium	72.63
Carbonate of lime	4.03
Phosphate of magnesia	1.93
Salts	0.61
Cartilage	19.58
Fat	1.22

In two portions of necrosed bone, occurring after fracture, the same chemist found:

	1.	2.
Organic matters	38.87	31.58
Inorganic matters	60.77	67.33
Fat	1.36	1.09

From these few analyses, we may admit the probability of there being, in necrosis, a slight diminution of the cartilaginous substance, and an increase of the calcareous salts, the adipose matter remaining unchanged.

SECT. V.—Tophaceous Deposits in Bone.

Marchand has published the two following analyses of tophaceous matters developed in the upper part of the femur and in the bones of the fore-arm, after an attack of chronic arthritis:

	Femur.	Radius and ulna.
Phosphate of lime	42.12	43.18
Carbonate of lime	8.24	8.50
Phosphate of magnesia	1.01	0.99
Animal matter	46.32	45.96
Fluoride of calcium, soda, chloride of sodium, and loss	2.31	1.37

Lehmann has likewise analyzed the bones of three persons affected with chronic gout, and whose ages varied from forty to fifty years:

	1.	2.	3.
Phosphate of lime	35.16	35.83	37.22
Carbonate of lime	8.41	9.82	8.99
Phosphate of magnesia	1.31	1.05	1.13
Soluble salts	2.93	2.03	1.82
Cartilage	38.14	38.26	40.03
Fat	12.11	13.37	9.15

We see that in these cases there was:

a. Decrease of the phosphate of lime;

b. Increase of the carbonate of lime;

c. Great increase of the adipose matter.

SECT. VI.—Of the Tophaceous Concretions of Gout.

We deem it proper to quote here, the analyses that have been made of the tophaceous concretions of gout, developed in the joints.

Properly speaking, the subject should find its place under the sixth chapter, in which we treat of newly formed organic products, and it is only on account of the resemblance of these concretions to the deposits previously mentioned, that we allude to them here.

It is generally admitted, that the gouty concretions which are so frequently found in the joints of the hands and feet, contain urate of soda in combination with a little urate of potash and lime, chloride of sodium, and a little animal matter.

Wollaston was the first to analyze these concretions.

The two following analyses, due to Laugier and Wurzer, may serve to give an idea of their composition:

	Laugier.	Wurzer.
Uric acid	16.7	20.0
Soda	16.7	20.0
Lime	8.3	10.0
Chloride of sodium	16.7	18.0
Animal matter	16.7	19.5
Chloride of potassium	...	2.2
Water	8.3	10.3
Loss	16.6	...

Pauquy and Bor found gouty concretions to contain urate of soda—urate of lime—an albuminous substance, but no chloride of sodium.

Marchand has given the following analysis of a gouty concretion found in the femoral articulation.

Urate of soda	34.20
Urate of lime	2.12
Carbonate of ammonia	7.86
Chloride of sodium	14.12
Water	6.80
Animal matter	32.53

Analysis of a gouty concretion found in the metacarpus of a man, twenty-two years of age. (Lehmann.)

Urate of soda	52.12
Urate of lime	1.25
Chloride of sodium	9.84
Phosphate of lime	4.32
Cellular tissue	28.49
Water and loss	3.88

Analysis of a gouty concretion by Lheritier.

Urates of ammonia, soda, and lime	49.0
Phosphate of lime	42.0
Organic matter and water	9.0

SECT. VII.—Exostosis.

M. Lassaigne has given the following analysis of three portions of the same bone, in order to ascertain the differences which may exist between healthy bone, the exostosis, and the portion of thickened bone upon which it is developed.

	Thickened bone.	Healthy bone.	Exostosis.
Phosphate of lime	36.3	41.6	30.0
Carbonate of lime	6.5	8.2	14.0
Soluble salts	14.2	8.6	10.0
Organic matter	43.0	41.6	46.0

Here the results are:

a. Increased proportion of the organic matters.

b. Proportion of carbonate of lime almost doubled.

c. Decrease of the phosphate of lime.

SECT. VIII.—Callosities.

M. Lassaigne has analyzed the external and internal portions of a large callosity, with the following results:

	External portion.	Internal portion.
Phosphate of lime	33.3	32.5
Carbonate of lime	5.7	6.2
Soluble salts	11.3	12.8
Animal matter	50.0	48.5

ARTICLE II.

OF THE TEETH.

In the teeth, as in bone, there are found phosphate and carbonate of lime, fluoride of calcium, and cartilage.

The teeth are covered over with the enamel, whilst upon their roots there is found a cortical substance, which also covers the enamel of the crown.

Of these three substances, the enamel, the bone, and the cortical substance, the latter contains the most organic matter.

Cortical substance, as analyzed by Lassaigne.

Organic matter	42.18
Phosphate of lime	53.84
Carbonate of lime	3.98

Analysis of the osseous portion, by Berzelius.

Cartilage and vessels	28.0
Phosphate of lime and fluoride of calcium	64.3
Carbonate of lime	5.3
Phosphate of magnesia	1.0
Soda and chloride of sodium	1.1

Pepys found the same substance to contain:

Cartilage	28.0
Phosphate of lime	58.0
Carbonate of lime	4.0
Water and loss	10.0

An analysis of the teeth, at different periods of life, has been made by Lassaigne. From his researches it would appear, that the proportion of phosphate of lime gradually increases, while that of the carbonate of lime undergoes a corresponding decrease.

	Organic matter.	Phosphate of lime.	Carbonate of lime.
Tooth of a child, one day old	35.00	51.00	14.00
„ of a child, six years old	28.57	60.01	11.42
„ of an adult	29.00	61.00	10.00
„ of a man, eighty-one years old	33.00	66.00	1.00

We quote from Berzelius, the following analysis of the enamel of a human tooth:

Phosphate of lime and fluoride of calcium	88.5
Carbonate of lime	8.0
Phosphate of magnesia	1.5
Membrane, alkali, and water	2.0

The following analysis of human teeth is by Von Bibra:

	Molar tooth of a woman, 25 years of age.		Molar tooth of an adult male.	
	Enamel.	Bony parts.	Enamel.	Bony parts.
Phosphate of lime, with a little fluoride of calcium	81.63	67.54	89.92	66.72
Carbonate of lime	8.88	7.97	4.37	3.36
Phosphate of magnesia	2.55	2.49	1.34	1.08
Salts	0.97	1.00	0.88	0.83
Cartilage	5.97	20.42	3.39	27.61
Fat	a trace	0.58	0.20	0.40

ARTICLE III.

OF CARTILAGE.

We possess a few analyses of healthy cartilage; but we know of no researches hitherto published respecting this tissue when diseased.

The following analyses, quoted from the essay of Von Bibra, may suffice to shew the composition of healthy cartilage.

Analysis of 100 *parts of incinerated cartilage.*

	Cost. cartil. of a child, 6 months old.	Cost. cartil. of a child, 3 years old.	Cost. cartil. of a girl, 19 years old.	Cost. cartil. of a woman, 25 years old.	Cost. cartil. of a man, 40 years old.
Phosphate of lime .	20.86	21.33	5.36	6.33	13.09
Sulphate of lime .	50.68	48.68	92.41	87.32	79.03
Phosphate of magnesia	9.88	8.88	0.99	4.10	3.78
Sulphate of soda .	9.21	10.93	1.24	0.95	1.22
Phosphate of soda .	traces	3.00	...	traces	0.93
Carbonate of soda .	traces	traces	...	traces	traces
Chloride of sodium .	9.37	7.18	...	...	...
Carbonate of lime .	...	...	...	...	traces

ARTICLE IV.

OF THE HAIR.

The hair has been analyzed by Scherer and Van Laer.

On treating hair with alcohol, æther, and water, we obtain: margarine—margaric acid, oleine—a brown substance, soluble in water, chlorides of potassium and sodium, and lactate of ammonia.

The following is, according to Van Laer, the composition of the organic matters of hair.

	Ash.	Soluble portion.	Peroxide of iron.	Insoluble portion.
Brown or chesnut hair . .	0.54	0.17	0.058	0.312
Ditto ditto . .	1.10	0.51	0.395	0.200
Ditto ditto . .	0.32	...	...	...
Black hair	1.02	0.29	0.214	0.516
Ditto	1.15	...	...	...
Red hair	1.30	0.93	0.170	0.200
Ditto	0.54	0.27	0.275	...
Ditto	1.85	...	...	...
Grey hair	1.00	0.24	0.232	0.528
Ditto	0.75	...	...	...

The soluble portion was found to be composed of chloride of sodium, sulphate of lime, and sulphate of magnesia. The insoluble constituents were phosphate of lime and silica.

ARTICLE V.

OF THE BRAIN, SPINAL CORD, AND NERVES.

Hitherto, the chemical analysis of these tissues has thrown no light upon the functions of the nervous system.

According to M. Couerbe, the cerebral substance contains five different species of fat, which are:

1. Cholesterine;
2. Eleencephole;
3. Cerebrote;
4. Stearoconote;
5. Cephalote.

The results obtained by M. Fremy are now generally accepted. This chemist found in the cerebral mass:

1. Albumen;
2. Cholesterine.

Two distinct acids, each containing phosphorus, viz.:

3. Cerebric acid;
4. Oleo-phosphoric acid;
5. Traces of oleine, margarine, oleic and margaric acids.

These four organic acids exist in combination with soda.

The fatty matters are almost exclusively found in the white substance of the brain.

M. Fremy has, likewise, discovered certain acids in the spinal marrow and nerves.

The proportion of water existing in the cerebral substance is considerable. The mean being, according to M. Fremy, 88 per cent.; and according to others, 80 per cent.

The same chemist asserts, that the 12 per cent. of solids contain 7 per cent. of albuminous matters, insoluble in alchohol, æther, and water, together with 5 per cent. of the different fats and their compounds.

We subjoin a few analyses.

Analysis of M. Denis:

	Brain of a man, 20 years of age.	Brain of a man, 78 years of age.
Water	78.00	76.06
Albumen	7.30	7.80
Phosphuretted fat	12.40	13.10
Extractive matter and salts	1.40	2.50

Vauquelin found the composition of human brain to be as follows:

Water	70.00
Albumen	7.00
Fat	5.23
Phosphorus	1.50
Extractive matter	2.12
Acids, bases, and sulphur	5.12

Analyses made by Lassaigne upon the brain of an insane person:

	Cortical and medullary substance combined.	Cortical substance.	Medullary substance.
Water	77.0	85.0	73.0
Albumen	9.6	7.5	9.9
Colourless fat	7.2	1.0	13.9
Red fat	3.1	3.7	0.9
Extractive matter, lactic acid, and salts	2.0	1.4	1.0
Phosphate of lime and magnesia, and peroxide of iron	1.1	1.2	1.3

M. Lheritier has given the following table, relative to the composition of the brain. Each figure stands as the mean of six analyses.

	Children.	Youths.	Adults.	Aged persons.	Idiots.
Water	82.79	74.26	72.51	73.85	70.93
Albumen	7.00	10.20	9.40	8.65	0.40
Fat	3.45	5.30	6.10	4.32	5.00
Osmazome and salts	5.96	8.59	10.19	12.18	14.82
Phosphorus	0.80	1.65	1.80	1.00	0.85

According to Vauquelin, the medulla oblongata and spinal cord contain the same elements as the brain, with the exception of a larger proportion of fat and a smaller amount of albumen, extractive matter and water.

M. Lheritier found the spinal cord of an adult to be thus constituted :

Water	71.05
Albumen	7.30
Fat	8.25
Osmazome	11.50
Phosphorus	1.90

According to the same chemist, the nerves contain a larger proportion of albumen and soft fat, but less solid fat than the brain.

ARTICLE VI.

OF THE CRYSTALLINE LENS AND HUMOURS OF THE EYE.

The crystalline lens is insoluble in boiling water, alcohol, and acids. It is composed of a distinct substance, somewhat resembling horny tissue. The membrane of Demours (the third layer of the cornea) possesses similar properties.

The specific gravity of the crystalline lens is 1.079 (Chenevix). It is more resistant in proportion to the age of the individual (Simon).

Berzelius has given the following analysis of the crystalline lens :

Water	58.00
Compounds of protein	35.90
Alcoholic extract and salts	2.40
Aqueous extract, with traces of salts	1.30
Membranous cells	2.40

According to Lassaigne and Wurzer, the opacity of cataract is due to an excess of phosphate of lime.

Simon asks whether this opacity be not dependent upon the presence of a free acid, possessing the power of coagulating the compounds of protein.

We thus see, that science is still much in arrear as regards our knowledge of the chemical composition of either the healthy or opaque crystalline lens.

Of the Vitreous Humour.—The fluid obtained from the membranes by expression, when evaporated to dryness gave 0.16 per cent. of colourless residuum, containing a certain quantity of chloride of sodium.

According to Berzelius, the composition of this fluid is as follows:

Water	98.40
Albumen	0.16
Chloride of sodium, with a little extractive matter	1.42
A substance soluble in water	0.02

Of the Aqueous Humour.—This humour was analyzed by Berzelius with the following results:

Water	98.10
Albumen	traces
Chloride of sodium, with a little alcoholic extract	1.15
Extractive matter, soluble only in water . .	0.75

ARTICLE VII.

OF THE LIVER.

The analyses that have been hitherto made of the liver, as well as of other glands, are in general defective; as it is impossible entirely to isolate the vessels, nerves, and cellular tissue which enter into their formation, from the blood with which they are to a certain extent infiltrated.

Frommherz and Gugert found the liver to be thus constituted:

Water	61.79
Solid residuum	38.21

100 solid parts were composed of 28.72 per cent. of insoluble matters, and 71.28 of soluble matters.

100 parts, when burnt, afforded 2.634 of salts, viz., chloride of sodium, phosphate, and a little carbonate of lime, phosphate of potash, and traces of peroxide of iron.

Frierich has published the two following analyses of fatty liver:

	1.	2.
Water	73.09	80.20
Solid constituents	26.91	19.80
Fat, containing phosphorus and cholesterine	17.26	2.20
Albumen	3.67	3.50
Vessels and hepatic cells . .	4.00	3.60
Aqueous extract	0.48	7.00
Alcoholic extract	1.50	3.50

M. Boudet has also analysed fatty liver. We shall place this analysis in juxta-position with that of the healthy organ.

	Fatty liver.	Healthy liver.
Water	55.15	76.39
Solid constituents	44.85	23.61
Animal matter, dried at 212° .	13.32	21.00
Saponifiable fat	30.20	1.60
Cholesterine	1.33	0.17

CHAPTER VI.

ORGANIC PRODUCTS OF NEW FORMATION.

We shall consider in this chapter, the chemical properties of pus, tubercle, and cancer.

We are aware of the difficulties which surround the subject, and shall consider ourselves fortunate, should our labours throw any light upon this department of science, hitherto so little advanced ; and more especially, should they induce some of our young physico-chemists to enter still further upon a path so little explored.

ARTICLE I.

PUS.

Pus is a morbid product, which can only be developed subsequent to, or as a consequence of acute or chronic inflammation. True pus, indeed, may be regarded as due to inflammation of cellular tissue, whether free, or interposed between the fibres of different organs.

It is this product which we shall consider in the present chapter, examining in succession its physical and chemical properties.

Physical Properties.—Pus is a yellowish, or greenish yellow liquid, of very variable consistence and density; it is composed of a fluid to which the name *serum of pus* (liquor puris) may be given, and of numerous corpuscles floating in the same. These are the pus globules.

These corpuscles are of a tolerably regular spherical form, more especially when the pus is of good quality. Their diameter varies from the $\frac{1}{200}$th to the $\frac{1}{300}$th of a line; they rarely attain the $\frac{1}{50}$th, and still more rarely do they fall below the $\frac{1}{400}$th of a line. Of the cause of these variations we know nothing.

The pus globules are sometimes pale and transparent; at others, opaque and rugous. This latter appearance is due to the presence of very minute granulations, of from $\frac{1}{1000}$th to $\frac{1}{500}$th of a line in diameter.

When isolated, they are colourless; but when agglomerated, they have a yellowish appearance.

When compressed under the field of the microscope, they are reduced to an amorphous mass. Pus corpuscles are organized bodies, having, for the most part, cells and nuclei.

The granular and rugous covering of these corpuscles often prevents the recognition of their nuclei. To examine them thoroughly, this external envelope must either be dissolved, or rendered transparent by means of acetic acid.

The nucleus is excentric, and fixed to the internal wall of the cell; sometimes, however, it is so large as to fill the entire cell. The nucleus is rarely single, but generally multiple, being composed of several smaller corpuscles. Under the influence of acetic acid or of a saline solution, it may be seen to break up into two, three, or four secondary nuclei. The constituent parts of the nucleus are sometimes elliptical, sometimes spherical or oval, at others, isolated or agglomerated. Occasionally, they are seen united in such a manner as to resemble a leaf of trefoil. Hence it is, that the size of the nuclei varies considerably, according as the entire nucleus itself is measured, or only the different portions of which it is composed. It varies from the $\frac{1}{800}$th to the $\frac{1}{400}$th of a line in diameter.

The thickness of the cell walls is very variable; sometimes they are thin, smooth, membranous and transparent (in recent pus); at others, they are thick, opaque and covered with small adherent granulations. The cell wall, in this last case especially, is not well defined externally: it is a nucleus, surrounded by a deposit, the outlines of which are not very distinct, but require artificial means to render them so.

Between the cell wall and the nucleus, more especially when this last does not fill the entire globule, there exists a small cavity. This cavity is probably not a vacuum, but contains, rather, a sero-albuminous fluid; this, however, is but a supposition. In some cases, this little cavity is filled with granular matter, and appears like a soft mass, in which the nucleus is embedded.

The action of chemical reagents upon pus elucidates, to a certain extent, the phenomena revealed by the microscope.

Two very interesting points of investigation here present themselves; the one is the endosmotic action of the corpuscles themselves; the other is the influence of reagents upon the cell walls and nucleus.

If the pus globules be treated with fluids of low specific gravity, containing but little saline matter, and more especially with distilled water, the globules absorb the water by endosmotic action and swell up. If, on the contrary, we employ dense solutions, saturated with salts (chloride of sodium, for instance), the globules shrivel up and diminish in volume: exosmosis here takes place.

In distilled water, pus globules swell up and become spherical; the cell wall at the same time becomes more transparent, and the nuclei are rendered more visible. If the action be prolonged, the endosmotic action may continue until the globules burst; they then become irregular, lobulated, and mutilated; still later, the nucleus itself may absorb fluid, and its granulations losing their primitive shape, may thus become spherical.

Under the influence of a concentrated and saturated solution of common salt, the pus corpuscles may be seen to retract and their diameter to decrease, from the $\frac{1}{220}$th to the $\frac{1}{300}$th or even $\frac{1}{400}$th of a line.

If, in this state, water be added, the globules regain their primitive form and size.

The action of chemical reagents when diluted, is conjoined with that of endosmosis, and in such case the phenomena are complex.

Diluted acids render the cell envelope transparent, and cause it to burst by endosmosis; this is effected more especially by acetic acid. The nuclei themselves are similarly affected.

Moderately diluted solutions of the neutral salts (chloride of sodium, sal ammoniac) after a time dissolve the cellular wall of the globules, and even a considerable portion of their contents, but have no solvent action upon the nuclei.

Alkaline carbonates, borax, and especially caustic alkalies, convert pus globules into a mucilaginous mass; their walls disappear, and nothing remains but minute granulations, of less than $\frac{1}{1000}$th of a line in diameter.

Substances which coagulate albumen (metallic salts, tincture of iodine, alcohol, etc.), render the pus globules turbid and opaque; this proves the albuminous nature of their contents, and that of the liquid which surrounds them.

When boiled with strong hydrochloric acid, the latter assumes a violet colour.

Vogel, to whom we are indebted for some of the preceding details, concludes from these different reactions, that the globules of pus are formed of various chemical substances, of which may be distinguished:

1. *The envelope or cell wall,* which is soluble in solutions of the alkaline carbonates and caustic alkalies, as also in those of borax; almost entirely soluble in saline solutions, such as those of nitre, sal ammoniac, etc., and especially so, in acetic acid. This substance, as we have just stated, corresponds to the cell wall, and to a portion of the contents of the cell itself. It is, according to Vogel, a compound of protein, or of some modification of albumen.

2. *The substance constituting the nucleus;* this is insoluble in acetic acid, but soluble in caustic alkalies, their carbonates, and borax. In saline solutions it becomes distended, and is regarded by Vogel as a combination of protein, or rather of modified fibrin.

3. *The substance constituting the small particles which remain after the pus corpuscles have been treated with caustic alkalies and borax.*—These molecules exist without the nuclei (they are not, therefore, always nucleoli), in the contents of the

cell, and probably even in the cell wall: they are either composed of a modification of protein analogous to keratin (Lehmann and Messerschmidt), or of fat.

These latter corpuscles are often the only bodies which the microscope reveals in pus, even of good quality. They are always very small, being less than the $\frac{1}{1000}$th of a line in diameter. Sometimes they float about separately, at others, in groups, in the serum of the pus. They are at one time, combinations of protein; at another, elementary granules; at another, pus globules in process of formation or aborted; at another, fat; more rarely there are present certain infusoria (*monades* and *vibriones*), as occurs in the pus of some ulcers.

Pus sometimes contains other substances; we may especially notice:

a. Epithelial cells;
b. Fragments of epidermis;
c. Crystals of cholesterine;
d. Crystals of ammoniaco-magnesian phosphate;
e. Exudation flakes of semi-organized or amorphous fibrin.

Chemical Properties of Pus.—The chemical history of this substance is still very imperfect; and in spite of the frequency with which it is met, the different principles entering into its composition are but little known in a qualitative, and still less so, in a quantitative point of view.

Güterbock was the first to make known the proper method of analyzing pus; it is as follows. The pus is first treated with anhydrous alcohol, in which it is boiled; it is then filtered while hot, the fat subsiding when cold. The clear alcoholic solution is evaporated, and the residuum treated with water which dissolves the extractive matter and a free acid, but leaves undissolved a small quantity of fat which had escaped the action of the spirit. The portion which is insoluble in boiling anhydrous alcohol, is freed from this latter by evaporation and then treated with water, which removes the pyin and some albumen, combined, probably, with soda. The insoluble portion consists of coagulated albumen and pus corpuscles. The salts are ascertained by the incineration of a certain quantity of pus.

Pus has been analyzed by Güterbock, Valentin, Golding Bird, Wood, Von Bibra, and Wright. The differences observed in the results obtained by these authorities are considerable.

Güterbock analyzed the pus derived from a mammary abscess. Valentin, that from a phlegmonous abscess of the thigh. Wood, the pus from the hand of a man, and from abscesses of the cheek and thorax in a female. G. Bird, that derived from a psoas abscess.

We quote the following analyses from Simon:

Güterbock.

Water	861.0
Solid constituents	139.0
Fat, soluble in hot alcohol	16.0
Fat and extractive matter, soluble in cold alcohol	43.0
Albumen, pyin, and pus corpuscles	74.0
Loss	0.0

Valentin.

Water	883.78
Solid constituents	116.22
Cholesterine	11.86
Oleate of soda, oleine and chloride of potassium	10.02
Stearine	6.85
Coagulated albumen and fibrin	79.78
Fluid albumen and chloride of sodium	19.34

Golding Bird.

Water	898.00
Solid constituents	102.00
Fat	5.00
Watery extract, with alkaline lactates	8.00
Albumen	75.75
Chloride of potassium and sodium, with carbonates	5.75
Phosphate of lime and iron	7.50

Wood.

Water	857.15
Solid constituents	142.85
Cholesterine	1.57
Oleate of soda	10.91

Extractive matter, chloride of sodium and other salts	8.34
Albumen	19.09
Animal matter possessing the properties of ptyaline and gluten	16.57
Fibrous matter with phosphate of lime, peroxide of iron, and sulphur	86.37

According to Güterbock, there are 5.7 of salts in 100 parts of solid residuum; of these, 5 are soluble in water, and consist, for the most part, of chloride of sodium, with a small quantity of phosphate, sulphate, and carbonate of soda, chloride of potassium and chloride of calcium: the remaining 0.7 of salts, soluble only in nitric acid, is made up of phosphate of lime and magnesia, carbonate of lime, and a trace of peroxide of iron.

Valentin estimates the salts at 5.32 per cent of solid residuum; of which 4.7 are soluble in water (chloride of sodium with traces of sulphate of potash, soda and lime, carbonates of potash and soda), and 0.62 insoluble in water (phosphate, sulphate and carbonate of lime).

The three following analyses are due to Von Bibra:

	Pus derived from an abscess of the cheek.	Pus derived from an abscess of the thorax.	Pus derived from an abscess of the neck.
Water	769.0	852.0	907.0
Albumen and pus corpuscles	160.0	91.0	63.0
Fat	24.0	33.0	9.0
Extractive matter	19.0	29.0	20.0

Analysis of Pus by Wright.

	Pus from a vomica.	Pus from a psoas abscess.	Pus from a mammary abscess.
Water	894.4	885.2	879.4
Fatty matter	17.5	28.1	26.5
Cholesterine	5.4		
Mucus	11.2	6.1	...
Albumen	68.5	63.7	83.6
Lactates, carbonates, sulphates, and phosphates of soda, potash, and lime	9.7	13.5	8.9
Iron	a trace	...	...
Loss	3.3	2.7	1.6

The following comparative analysis of pus-serum and blood-serum is due to Nassé:

	Serum of pus.	Serum of blood.
Water	890.00	906.5
Solid residuum	110.00	93.5
Organic constituents	92.58	85.7
Chloride of sodium	12.60	4.6
Carbonate of soda	2.22	1.4
Phosphate of soda	0.32	0.9
Sulphate of soda	0.18	0.2
Phosphate of lime	1.20	0.7
Carbonate of lime	0.90	

Simon, Martens, Bostock and Vogel have each analyzed pus; the results obtained present, however, nothing specially deserving of notice, and differ from one another as much as those which we have already quoted.

Whence, then, these discrepancies? How is it that no two analyses are the same? The researches upon which we have for some time past been engaged, and which form the subject of an hitherto unpublished memoir, enable us to discuss this question, and to offer an explanation which we consider to be plausible. We shall here, therefore, detail the results of these investigations, which comprise a large number of qualitative analyses, and nine quantitative analyses.

Phlegmonous pus (*i.e.*, ordinary pus) is composed of a serous fluid, containing pus globules in various proportions.

This serum, owing to its peculiar composition, possesses the power of holding the pus corpuscles in suspension, and, as it were, in the form of an actual emulsion.

The serum of pus is thus composed:

1. *Of water*, the quantity of which is liable to such variation, that we are unable to give the mean proportion. It oscillates between 950 and 800 in 1000 parts of pus. We shall presently explain the influence exerted by this variable proportion of water.

2. *Of albumen in solution.*—This albumen is absolutely identical with that of the blood: it is coagulated by heat and

nitric acid, and possesses the property of deviating to the left, the ray of polarized light.

3. *Of extractive matters* very similar to those of the blood, but of which the true nature has not as yet been determined.

4. *Of seroline*, a fatty matter in every respect identical with that found in the blood, and possessing the same properties as those assigned to this product by M. F. Boudet, in his remarkable work on the fatty matters of the blood.

5. *Of cholesterine.*—This fatty substance is found to a considerable extent in pus.

6. *Of the fatty matter* to which the name *animal soap* has been given, and which is a combination of oleate, margarate, with a little stearate of soda.

What, we may here ask, is the cause of these substances being held in solution by the serum of the pus?

The question is not without importance, for we ourselves consider, that it is to the combination of these fatty matters with the serum of the pus, that this latter owes its oily consistence, its unctuousness; and upon this property, moreover, depends the state of emulsion in which the pus globules are found.

It is asserted by some, that this latter phenomenon may be explained by the existence of a small quantity of the peculiar principle found in mucus, viz., *mucine* or *mucosine.*

Others admit the existence of a principle, to which they have given the name of *pyin* (Güterbock and the majority of his followers).

We have never been enabled to discover the pyin, or to recognize the characteristics assigned to it by this author, and we rather lean to the idea that this pretended pyin is but a modification of albumen.

Pus is found to contain a considerable proportion of salts; these, as obtained by incineration, are as follows:

Chloride of sodium, in combination with a minute proportion of *chloride of potassium.*

Soluble salts of soda, in combination with a small quantity of *the salts of potash*, viz., *carbonates, sulphates*, and *phosphates*.

Phosphate of lime, with a little *phosphate of magnesia*, and a small quantity of peroxide of iron.

There is, however, another point of view in which pus must be regarded, viz., with reference to the ratio which exists between the water on the one hand, and the solid constituents on the other. Upon this hinges the whole question; here it is that we meet with a solution of those discrepancies which have been found to exist between the analyses of different authorities; it explains them, in fact, perfectly; and if in future researches, this relationship or ratio be borne in mind, the comparison of different specimens of pus derived from different organs will be much simplified.

To establish this ratio between the water and the solid matters of the pus, two things are necessary:

1. To ascertain the exact quantity of each; and

2. To take the solid matters, whatever may be their proportion, and then to refer the analysis of the different principles of which they are composed, to the standard of 100.

It may, for instance, happen, that a specimen of pus which, as regards weight and the nature of its solid constituents, is exactly similar in composition to another specimen, will yet seem to differ from it entirely, inasmuch as the same amount of solid material is diluted with a greater or less proportion of water. If, then, in these two specimens of pus, apparently so dissimilar in composition, we refer the aggregate of the solid matters to the standard of 100, we shall rediscover their identity of composition, and be enabled to compare them with one another.

We have adopted this method in our own analyses of pus, and with what results will presently be seen.

The following is the process which we suggest: it enables us to ascertain with tolerable accuracy the constituent principles of pus.

In order to obtain a somewhat exact analysis, it is necessary to employ at least fifteen drachms of pus, and with this small quantity it is absolutely indispensable that the operation be performed with the greatest care, in order to obtain a ponderable amount of each of the solid constituents of the pus. To avoid the chance of error, indeed, we would advise the process to be carried out upon the greatest possible quantity of this fluid.

The pus about to be analyzed (say three ounces) is first divided into four equal parts. Each of which is thus treated :

1. The first portion, the weight of which has been accurately ascertained, is dried in a stove at a temperature of from 80° to 90° (centigrade measure), it is then weighed after desiccation, calcined with great care in a platinum crucible, and again weighed.

The results of this part of the process, when referred to 1000, give :

The weight of the water ;

The aggregate of the solid constituents ;

The weight of the salts.

These last are then analyzed in a manner similar to that which we have already described when speaking of the salts of the blood.

2. The second portion of pus is to be treated and boiled with five times its weight of anhydrous alcohol. It is then filtered, and the residuum left on the filter is washed with æther, dried, and weighed.

This last portion contains the coagulated albumen and the pus corpuscles. To it must be added the weight of a small quantity of albumen which the alcohol removes during filtration ; this must be isolated, and weighed separately.

3. The third portion is to be carefully dried, weighed, pulverized, and treated with distilled water, in which it is to be boiled. It must be filtered, dried, and again weighed. The difference gives the weight of the extractive matters, of the chloride of sodium, and of the soluble salts.

The residue is now treated with rectified spirit, in which it is boiled. The compound thus formed is subjected to the same series of operations which have already been described in the section relative to the fatty matters of the blood, and we thus obtain the seroline, the animal soap, and the cholesterine.

4. The fourth and last portion is now treated with five times its weight of cold distilled water, and smartly shaken. It is then filtered, and the filtered product coagulated by heat. This coagulated matter is dried and weighed: the weight thus obtained indicating the proportion of albumen.

This proportion is, however, in general, somewhat below the actual amount, inasmuch as there remains a small quantity of albumen on the filter. The above method of procedure, therefore, should only be employed when the pus ceases to afford serum, either on standing or on being filtered.

When the serum of pus, however, can be procured, we are much more certain respecting the weight of the albumen. In this case the serum is to be coagulated, then filtered, and the product thus afforded, washed with distilled water, alcohol, and æther and then dried. In this way pure albumen is obtained.

By the above series of operations we procure:

a. The albumen and pus globules;
b. The extractive matters and soluble salts;
c. The soluble and insoluble salts;
d. The albumen.

The weight of each individual constituent may be ascertained thus:

The soluble salts being subtracted from the sum total of the extractive matters, we obtain the exact weight of these latter.

We then subtract the weight of the albumen from that of the pus corpuscles.

In our own analyses we have always referred the weight of the solid matters to the standard of 100.

The following table contains nine analyses of pus, made after the above method.

The table is divided into four parts:

The first contains the analysis of 100 grammes of dried pus;

The second shews the amount of water necessary to reconstitute pus in each of these varieties;

The third, the relative proportion between the water and the solid matters contained in 1000 parts of pus;

The fourth indicates the weight of the salts, with the details of their analyses.

The two first analyses refer to sero-purulent fluids;

The third and fourth, to phlegmonous pus;

The fifth, sixth, and seventh, to that derived from carious bone;

The eighth and ninth, to the same pus after fifteen days interval. (See TABLE opposite.)

An examination of this table leads to important results.

In the first place, it may be laid down, that all the different constituents of pus are found likewise to exist in the blood; we may readily, therefore, conceive the origin of this pathological production. The pus corpuscles alone are of new formation; and it is not improbable, that even these may be developed at the expense of the fibrin.

If, however, all the elements of pus are found in the blood, we must admit that their proportions are not the same in each.

We may now proceed to institute a comparison between the results obtained in the nine preceding analyses, so far as the constituents of pus and their relative proportions are concerned.

1. *The water.*—It may be seen, that in 1000 parts of pus, the quantity of water is exceedingly variable; 796.300 being the minimum, and 916.850 the maximum.

We obtain similar results, on examining the amount of water necessary to dissolve the same proportion of the solid matters of pus. This quantity varies from 1101.89 to 391.83.

2. The aggregate of *solid materials* also varies to a great extent. Thus, 83.150 may be regarded as the minimum and 203.320 as the maximum.

If, now, we take each of the solid constituents separately, we obtain the following results:

a. The *albumen* was most abundant in the cases of sero-purulent effusion.

Table shewing the composition of pus (from an unpublished memoir by MM. Becquerel and Rodier).

		Pus from a sero-purulent effusion.		Phlegmonous pus.		Pus from an abscess produced by carious bone.				
		1. In a case of puerperal peritonitis.	2. In a case of sero-purulent effusion into the pleura.	Pus from an abscess of the iliac fossa.	Pus from a phlegmon of the thigh.	Abscess of the thigh.	Abscess resulting from caries of the vertebræ.	Abscess of the shoulder, the result of caries.	Abscess from caries of the great trochanter.	The same, after fifteen days interval.
		Composition of 100 parts of dried pus.	Composition of 100 parts of dried pus.	Composition of 100 parts of dried pus.	Composition of 100 parts of dried pus.	Composition of 100 parts of dried pus.	Composition of 100 parts of dried pus.	Composition of 100 parts of dried pus.	Composition of 100 parts of dried pus.	Composition of 100 parts of dried pus.
First Portion.	Albumen	20.972	19.830	15.400	15.770	18.630	11.205	18.315	11.806	15.187
	Extractive matters . .	19.005	19.301	11.370	14.554	18.815	12.195	19.741	13.002	16.219
	Pus globules . . Salts . . .	33.625	35.601	36.470	51.008	33.294 { 26.004 7.200 }	42.606 { 32.819 9.789 }	37.318 { 29.186 8.127 }	59.093	49.324
	Seroline	1.445	1.195	3.264	1.040	2.372	1.610	1.871	1.875	2.279
	Cholesterine . . .	9.041	6.045	7.916	7.627	8.985	6.219	12.740	7.102	5.548
	Animal soap . . .	15.912	18.028	26.580	9.121	17.904	16.163	17.000	9.122	11.443
	Total . .	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Second Portion.	Amount of water necessary to restore these 100 parts to the condition of fluid pus .	1,101.890	870.180	840.000	301.000	924.410	1,087.640	835.020	626.740	533.320
Third Portion.	Amount of water in 1000 parts of pus . .	916.850	897.770	880.923	796.630	902.328	915.850	895.130	862.440	843.390
	Amount of solid matters in 1000 parts of pus	83.150	102.230	119.077	203.320	97.618	84.150	104.870	137.560	156.610
Fourth Portion. (the salts.)	Chloride of sodium . .	..	..	..	..	4.664	5.873	5.420	..	..
	Soluble salts of soda, with a little potash .	..	..	..	..	1.876	3.118	1.957	..	..
	Phosphates of lime and magnesia . .	..	..	..	..	0.610	0.702	0.587	..	..
	Peroxide of iron . .	..	..	..	..	0.050	0.096	0.163	..	..
	Total . .	..	..	..	..	7.200	9.789	8.127	..	..

It was much diminished in the two cases of phlegmonous pus, being the same in each.

Lastly, in the five cases of abscess from carious bone, it varied from 11 to 18 per cent. of the solid matters. Whence these differences? This question we are unable satisfactorily to answer at present.

b. The *extractive matters,* the nature of which is undetermined, and whose composition is as complex as that of osmazone, were represented by the same figures in the two cases of sero-purulent effusion, viz., 19.005 and 19.301.

In the two specimens of phlegmonous pus, the proportion of extractives was small (11.370 and 15.554).

In the five cases of abscess from carious bone, the variations were still more marked. Thus, they oscillated between 19.741 and 12.195.

c. The globules were not completely isolated, but remained in combination with the free salts and the pyin, if, indeed, we can admit the existence of this latter substance, which we have already stated to be, in all probabilty, a modification of albumen.

d. As for the *free salts,* they were only isolated in three cases.

On taking, however, the aggregate of these matters, we find: That the pus corpuscles are much less abundant in cases of sero-purulent effusion;

That they are proportionately more numerous in specimens of phlegmonous pus;

And that they are, likewise, abundant in pus derived from abscesses, the result of caries.

e. The *seroline* presents characteristics similar to those of blood seroline. It was always present, and its proportions, referred to 100, varied but little throughout the whole series of experiments. Thus, its maximum was 3.264, and its minimum 1.195.

The smallest proportion of seroline was met with in the cases of sero-purulent effusion (1.445 and 1.195). The quantity was large in phlegmonous pus, and variable in that resulting from caries.

f. The *cholesterine* varied considerably in the two cases of sero-purulent effusion (9.041 and 6.045). Its proportions were almost identical in the two specimens of phlegmonous pus (7.916 and 7.627). In the five specimens of pus resulting from carious bone, this substance varied from 12.740 to 5.548. We are unable to assign a cause for such variation.

g. The *animal soap* varied likewise: thus, 15.912 and 18.028 were the proportions in the two cases of sero-purulent effusion; 25.580 and 9.121, in those of phlegmonous pus, and in that resulting from caries, it varied from 17.922 to 9.122.

h. As for the *salts,* we can merely state, that three analyses are insufficient to enable us to lay down any rule concerning them. It is, however, worthy of notice, that they were tolerably abundant in each case, and were mainly composed of chloride of sodium.

We have quoted these nine analyses, simply as a specimen of what may be done with regard to pus, but it is not our intention to draw any general conclusions from so limited a number of facts.

It would be very desirable that numerous analyses of each variety of pus should be made, according to the method just described; for we believe that many useful and valuable conclusions might thus be arrived at.

ARTICLE II.

OF TUBERCLE.

The chemical history of tubercle, generally considered, is so intimately connected with a portion of its pathological anatomy, that it is absolutely necessary to enter into a few details respecting this latter.

Tubercle must be studied: 1. In its crude state; 2. In the softened state; 3. In the stage of vomica; 4. In that of transformation or cicatrization.

Crude tubercle.—It is generally admitted, since Laennec's time, that tubercle may exist in two distinct forms: 1. As grey, semi-transparent tubercle; and, 2. As yellow tubercle.

Grey semi-transparent tubercle presents itself under the form of a colourless or bright greyish white tissue, of about the consistence of cartilage.

Yellow tubercle appears in the form of a homogeneous mass, of a yellowish white colour. It is more friable and of less consistent texture than the preceding.

It is still generally admitted, that crude tubercle is but a consequence of the evolution of grey semi-transparent tubercle. We see, in fact, during the second phase of its development, a yellow opaque point, appearing at first in the centre of the grey tubercle; this point, or points, for there may be several of them, spread, and at length end by invading the entire morbid product, in which no trace of its grey semi-transparent condition can any longer be discerned.

Can yellow tubercle be primitively developed as such? This is a question which has not, as yet, been definitely answered.

Tubercles, whether grey or yellow, may exist in four different conditions: 1, as granular tubercle; 2, as tubercle, properly so called; 3, as tubercular infiltration; 4, as encysted tubercle.

1. *Granular tubercle* appears as a small roundish or ovoid-shaped body, sometimes irregular or angular, varying in size from that of a millet seed (miliary granulation) to that of a hemp seed or very small pea (granulation, properly so called). These granulations, although usually isolated, are scattered to a greater or less degree throughout the pulmonary tissues, which still remain healthy and pervious in their immediate vicinity. They are composed of grey semi-transparent tissue, of yellow tissue, properly so called, or of both; in either case, the yellow portion is, for the most part, central.

A question here suggests itself, as to whether the yellow tissue, properly so called, can be primarily developed as such, or whether it be but a phase in the development of the grey semi-transparent tissue. Both of these opinions have been, and still are, held by pathologists; we conceive it, however, impossible, in the actual state of science, to deny, that yellow granular tubercle may actually be developed as such, without passing through the stage of grey, semi-transparent tubercle.

2. *Tubercle proper.*—True isolated tubercle is, in some sort, a large granulation; it may be formed either by the addition of tubercular molecules to an ordinary granulation, or by the union of several of these last, which being situated in the vicinity of one another, at length, by their progressive increase, approximate and unite. The union of these granulations may likewise be brought about by the interposition and deposition of grey, semi-transparent tissue.

This form of tubercle varies in shape and size; sometimes it is completely spherical, at others, its conformation is irregular. It is usually composed of yellow tubercular matter, and the tubercle itself is not unfrequently found either encircled with a small zone or band of the grey matter, or intersected by bands of this same matter, derived from the tissue by which the granulations have been united.

Tubercular infiltration.—Tubercular infiltration consists of a deposit of grey, semi-transparent, or yellow tubercular tissue, which occupies a certain extent of lung and may be present under the following conditions.

Sometimes it is deposited around the granulations, which it unites. At others, it is similarly deposited around true tubercles, the result being, not unfrequently, a mass sufficiently large to occupy almost an entire lobe of the lung, and composed of grey semi-transparent tissue in some parts, yellow tissue in others, with crude or softened tubercle disseminated throughout. In certain conditions, the deposition of grey semi-transparent tissue takes place around tubercular excavations.

Lastly, we sometimes see, in children especially, the grey semi-transparent infiltration primarily invade the tissues of an organ; occasionally, indeed, succeeding an attack of inflammation in this same organ.

When deposited in any tissue, it often happens, especially if several different localities be simultaneously invaded, that the grey semi-transparent matter compresses the interposed tissues, condensing and rendering them impermeable, and hence those apparently fibrous intersections, which are so numerous in parts that are the seat of tubercular infiltration.

4. *Encysted tubercle.*—This variety is somewhat rare; it consists in the formation, around the tubercle, of a membrane which, while sometimes fibrous and at others cartilaginous, is intimately adherent, on the one hand to the tubercular matter, and on the other to the tissues of the organ.

We have thus described tubercle in its crude state, and this description, accurate as it is, so far as the characteristics appreciable by the naked eye are concerned, may be considered as a result of the admirable anatomico-pathological researches of Bayle, Laennec, Louis, etc. More recently, an attempt has been made to penetrate still further into the structure of tubercle, and the microscope has contributed, not a little, to throw light upon this pathological production. About twenty years ago, M. Ruhen was the first to give a microscopic description of tubercles: he considers them as constituted by an agglomeration of small irregular yellowish bodies or corpuscles, united by ramifying or anastomosing hyaline filaments; around these corpuscles and filaments, is a species of mucous membrane-like envelope surrounding this newly-formed tissue, which M. Kuhm designates *tuberose tissue.*

Unfortunately, subsequent researches have not confirmed the results obtained by M. Kuhm.

It is to M. Vogel that we are indebted for the first real insight into the molecular constitution of tubercle. The following is a concise summary of his researches.

The different elements of which tubercle is composed are of various kinds. We find: 1. An amorphous, transparent, vitreous substance, or stroma, occurring in large masses, which perfectly resemble coagulated fibrin. 2. Of small grains (molecular granules) from $\frac{1}{800}$th of a line in diameter, to inappreciable minuteness; the majority having a rounded form. Their composition varies; some appear to be modified protein compounds; others consist of fat. Between them, moreover, we often find large fat globules; lastly, some of these granules are composed of calcareous salts (phosphates, carbonates).

3. Of imperfectly developed cells and cytoblasts, with or without nucleoli. These cells are, generally, very imperfectly developed, and a distinct nucleus can seldom be recognized. Their size usually varies from the 400th to the 300th of a line, their diameter rarely attaining the 200th of a line.

These three elements of tubercle vary considerably. Rarely does the amorphous stroma predominate; more frequently the granulations, and especially the granules of protein. Sometimes, however, the calcareous granules preponderate in certain cases (cretaceous transformation). They differ, moreover, according as they are examined in one or other of the varieties of tubercle generally admitted.

In the first (viz., grey infiltration, or greyish white, semi-transparent, homogeneous tubercle), the amorphous stroma and cellular formations predominate. In the second (yellow, opaque, lardaceous tubercle), the granular elements predominate, and explain the opacity, yellow colour, and granular texture of yellow tubercle.

According to Vogel, this second variety may, like the first, be primarily developed as such; his researches seem to prove this.

Some few years after Vogel, M. Lebert published the results of his labours, which present a remarkable analogy to those of the professor of Giessen. They are as follows.

According to M. Lebert, tubercle contains seven elements, three of which are constant, while four are of variable occurrence. Of the three first, one alone is characteristic, viz., the tubercular corpuscle or globule; the two others are the granules and the inter-globular substance. The corpuscles are of a pale yellow colour and irregular form, but more or less round or ovoid. Their edges, which are usually angular, and with rounded angles, when seen sideways, are rather polyhedral when made to float. No granules adhere to their surface, which is smooth. Their size varies from the $\frac{1}{3500}$th to the $\frac{1}{3000}$th, or $\frac{1}{2500}$th of an inch in diameter. The contents of these globules consist of a more or less transparent mass, sometimes granular; and of molecular granules, to the number of

four, five, six. and upwards. Occasionally, a species of void o
vacuum may be observed in the mass.

The molecular granules, whose diameter varies from th
$\frac{1}{800}$th to the $\frac{1}{400}$th of a millimetre, are disseminated throughou
the whole tubercular mass, and are sometimes so numerous a
to appear to constitute it entirely. The majority are extern
to the tubercular corpuscle ; very few are found in its interio

The third constant element of tubercle is the inter-globul
substance, which serves to unite the corpuscles and granules
it is semi-transparent, of a greyish yellow colour, and tolerabl
consistent.

The non-constant elements of tubercle are: 1. Fat, in th
form of granules of elain and stearine, as also in that of smal
vesicles; 2. Melanotic matter, in the form of grains, spots, o
melanotic globules filled with black matter; 3. Fibres, whic
are but rarely seen; 4. Crystals of a prismatic form, which
however, are likewise seldom met with.

Such is the present state of science relative to the micro
scopic structure of tubercle. There is, however, another aspec
under which this morbid product may be viewed, viz., as re
gards its chemical composition. The following are the result
afforded by analysis, up to the present period.

According to Thenard, 100 parts of tubercular matter con
tain 98.5 of animal matter, 1.85 of muriate of soda, phosphat
and carbonate of lime, and traces of iron.

According to Reicht (Lobstein's *Pathological Anatomy*
6 grammes (90 grains) of tubercular matter, contained 1.4 g
of albumen, 1.2 gr. of gelatine, 1.8 gr. of fibrin, and 1.6 gr. o
water or loss.

According to Reuss (of Berlin), 100 parts of tubercular mat
ter, dried at a temperature of 100°, contain :

1. Cholesterine, 4.94;
2. Oleate of soda, 13.50;
3. A special substance, sea salt, lactate and sulphate o
soda, 8.46.
4. Casein, sea salt, sulphate and phosphate of sod
7.90;

5. Insoluble casein, oxide of iron, phosphate of lime, carbonate of lime, magnesia, sulphur, 65.11.

Total, 99.91.

M. Felix Boudet has published some interesting researches, which, however, refer rather to the composition of pulmonary tubercle, and to the comparison of this composition with that of the pulmonary parenchyma. According to this author, tubercle yields gelatine to boiling water, and albumen to cold water, together with a substance analogous to casein and not unlike fibrin, which is precipitated by acetic acid. The addition of alcohol demonstrates the existence of oleic and margaric acids, of neutral fat (oleine and margarine), lactic acid, lactate of soda, extractive matters, cerebric acid, and especially of cholesterine, which constitutes about the twentieth part of the dried tubercular mass. When incinerated, we find, moreover, chloride of sodium, phosphate of lime, a little carbonate of lime, sulphate and carbonate of soda, silica, oxide of iron and lactic acid.

Tubercle, when once developed, cannot remain long in this condition. Its essential peculiarity is to obey the laws of its evolution and to undergo further transformations. Three varieties of transformation may occur. The first, and by far the most frequent, is that of softening; the second, is the melanotic or sooty transformation; and the third, the cretaceous transformation. These we shall now examine in succession.

Softening of tubercle.—The mode in which the softening of tubercle takes place, suggests several important questions. And first, we may ask, can the grey, semi-transparent, tubercular matter undergo the process of softening? We think it probable, if not almost certain, that it cannot, and that to attain this condition, it must first undergo the yellow transformation. As for the yellow tubercle properly so called, whether developed as such, or as a consequence of the evolution of the grey matter, it alone softens.

Tubercle, in general, begins to soften at its centre; peripheral softening is much less frequent. In either case, the yellow matter becomes, at first, moist and greasy to the touch; at last, resembling thick, yellow or greenish pus. Occasionally, this liquid separates into two parts; the one, fluid, colourless, and almost transparent; the other, opaque, whitish, and cheesy.

We are indebted to Vogel for a very accurate microscopic investigation of the fluid derived from the softening of tubercle, and of the method by which this process takes place. "The amorphous stroma becomes first liquefied, and then the elementary granules separate from one another; at the same time the cells and cytoblasts become free, in part break up, and produce thus a sort of emulsion, by their admixture, either with the pre-existing, or a newly secreted fluid. The tissues, in the centre of which the tubercles are deposited, participate, for the most part, in this species of fusion; they soften with greater or less rapidity, according to their density, and the product of their disintegration becomes mixed up with the softened tubercular mass. The thick puriform fluid thus produced constitutes, therefore, a species of organic detritus, a collection of fragments saturated with serous fluid, and under the microscope exhibits very indefinite characters, resembling, in fact, a mass of elementary granules with incomplete cells and more or less perfect cytoblasts. Sometimes we notice crystals of cholesterine, or of ammoniaco-magnesian phosphate, together with certain other organized formations derived from the neighbouring tissues."

The views expressed in this passage, appear thoroughly conformable with the truth; nor, indeed, do we hesitate to adopt them. It is useless, therefore, to discuss the question as to whether the cause of the softening process be inherent in the tubercle itself, or be simply a consequence of the purulent secretion from the surrounding tissues, which, infiltrating the tubercle, disintegrates and softens it; a question, indeed, which has been vehemently discussed during the last twenty years.

The softened mass tends, for the most part, to eliminate itself, and, in this point of view, acts in a manner similar to the pus of an ordinary abscess. The medium through which this elimination takes place, varies according to the organ or tissue affected.

As soon as the eliminative process has been accomplished, we find, in place of the tubercular matter, an excavation presenting the following characteristics :

The tubercular excavation varies in point of size. Its walls are generally anfractuous, unequal, irregular, and formed, either by the parenchyma of the organ in which the morbid product was originally developed, a parenchyma itself infiltrated with tubercular matter, or by a false fibrous membrane, strongly adherent to the surrounding tissue.

This false membrane almost invariably shews the cavity to be of long standing. This cavity is seldom found either full or empty ; but it usually contains a small quantity of purulent fluid, secreted by its adjacent walls.

These cavities last, for the most part, as long as the patient lives. It sometimes, however, happens that, having, as we have just stated, become lined with false membranes, beyond which there exists no infiltrated tubercular matter, they may at length become obliterated, and present the appearance of an actual cicatrix. In such a case, the size of the cavity gradually diminishes, its walls mutually approximate, suppuration becomes more scanty, and the parietes end by coming in contact, the false membrane lining one side of the cavity becoming closely adherent to that of the other. Such is the origin of many of those cicatrices, found occasionally in certain organs, and more especially in the parenchyma of the lungs.

Tubercles, when once developed, tend, in the immense majority of cases, to softening and expulsion from the organ in which they have been developed. Some, however, appear to undergo certain other species of transformation, which are justly considered as modes of cure : these are :

1. *The melanotic or sooty transformation.*—Under this head, we comprehend that to which M. Boudet has given the name of *black matter*. The tubercle is of moderate consist-

ence, and unctuous to the touch; while numerous points or black streaks are seen, both on its surface and in its interior. These gradually extend, and, not unfrequently, the recently formed matter becomes perfectly black. The microscope and chemical analysis demonstrate the presence of a large amount of fatty matter; this new formation would seem to depend on an excess of molecular fat granules.

2. *The calcareous or cretaceous transformation.*—This is of more common occurrence than the preceding, and constitutes those chalky formations, not unfrequently met with in the aged. The new substance is composed of a great number of small, whitish, friable grains, not unlike plaster; or of hard, stony particles, which are either opaque or transparent. These are, at first, very small, but they gradually increase and become agglomerated, so as to take the place of the tubercular matter.

The matter thus transformed is generally enclosed in a cyst having fibrous or fibro-cartilaginous parietes.

These calcareous concretions have been analyzed by M. Felix Boudet. 100 parts, when deprived of all animal matter, dried at 100° centigrade measure, calcined, and then exhausted with distilled water, gave per gramme:

Soluble salts	0.701
Residuum	0.295
	0.996

The residuum was chiefly composed of phosphate of lime, with a small quantity of carbonate of lime, silica, and oxide of iron. The soluble salts were the chloride of sodium, phosphate and sulphate of soda.

The calcareous or cretaceous transformation of tubercle is due to an excess of saline molecular granules, as shewn by the microscope.

We shall terminate the microscopic and chemical history of tubercle, by quoting two quantitative analyses, taken from the work of Simon:

Analysis of a tubercular mass deposited in the liver.

Water	826.04
Solid constituents	173.96
Fat removed by æther, consisting of olein and margarine	18.63
Alcoholic extract	21.75
Aqueous extract, with some traces of pyin	8.34
Insoluble organic residuum	120.34
Fixed salts	4.90

Analysis of tubercular masses found in the abdominal cavity.

Water	893.82
Solid constituents	106.18
Fat	25.40
Casein and alcoholic extract	12.39
Pyin and watery extract	6.19
Salts	7.43
Crude tubercular matter	54.55

ARTICLE III.

OF CANCER.

We shall, according to our usual method, first review the physical characteristics of cancer, dwelling especially upon the microscopic researches made respecting them, both in France and elsewhere. We shall then consider the chemical composition of this newly formed product, and endeavour to ascertain, as far as possible, what resources the practice of our art is capable of drawing from the information thus obtained.

SECT. I.—Of the Physical and Microscopic Characteristics of Cancer.

The microscopic examination of cancer dates from about twenty years past. We shall endeavour to give a sketch of the same, by dividing its history into three phases, as represented by three authorities, whose researches we shall briefly comment upon: Vogel, Lebert, and Forster.

These three phases correspond to three different periods.

Vogel represents the microscopic investigation of cancer, originating and developing itself with such rapidity in Germany, as to lead to the belief, that it was about to reach, at a bound, the highest degree of precision.

We consider M. Lebert to be the personification of the introduction of the microscopic study of cancer in France, and of the discussion to which the results obtained by the Germans gave rise.

Lastly, M. Forster represents (if we may so speak) the reaction which has taken place. He denies the accuracy of the results hitherto obtained, as also the assertion, that nothing further remains to be done, in the microscopic investigation of cancer.

We shall now give a short summary of the researches of the above-mentioned observers.

The histological elements which constitute cancer are tolerably numerous, and require to be reviewed in succession.

1. *A firm amorphous substance, closely resembling coagulated fibrin.*—It becomes transparent on the addition of acetic acid, ammonia, and other caustic alkalies, and contains a large number of molecular granules consisting for the most part of modified protein or fat. This is the *cytoblastema* or nidus, from which are subsequently developed the elements of cancer.

2. *Molecular granules.*—These appear to consist partly of a modified protein compound, and partly of fat. They are occasionally accompanied by large fat globules; rarely are they constituted by calcareous salts. In the softened portions of cancer they are very numerous.

3. *Cellular structure.*—This is a very important element, which, while rarely wanting, occasionally preponderates to such a degree, as to constitute almost the entire pathological formation (as in encephaloid).

According to Vogel, there are two varieties of cells: the one is the *cancer cell* properly so called, which always remains as such; the other, a transition cell, which may be converted into some other tissue, more particularly the fibrous.

Cancer cells.—They vary considerably, from the simple cytoblast up to the perfect cell. These varieties correspond to different degrees of cancerous development.

The nuclei of these cells are from $\frac{1}{450}$th to $\frac{1}{250}$th of a line in diameter. They sometimes contain nucleoli, and are insoluble in acetic acid.

The round or oval cells vary from the $\frac{1}{300}$th to the $\frac{1}{100}$th of a line in diameter, and are soluble in acetic acid and caustic alkalies.

The following varieties are most frequently met with.

a. Peculiarly formed, caudate, ramifying cells.

b. Cells containing a large number of nuclei (from twenty to thirty), or enclosing in their interior recently formed but perfect cells. Their diameter varies from the $\frac{1}{100}$th to the $\frac{1}{30}$th, or even to the $\frac{1}{20}$th of a line.

c. Cells with thick walls and a double contour.

d. Double cells, resulting from the division of one, or the fusion of two cells.

e. Cells filled with granules, together with others in which granules appear to be scattered over the surface.

f. In certain cancers there are found cells of various shapes and sizes, containing a granular pigment, usually of a black colour.

These different forms of cells not unfrequently pass from one to the other, by more or less marked transitions.

Hence it follows, says Vogel, that the term cancer cell can only be applied to one determinate form of cell differing from every other, and that on examining a single cell under the microscope, it is impossible to say whether it be cancerous or not; but that frequently all doubt is cleared up, when a mass of cancer cells is examined, and this, as much on account of the diversity which they present, as on that of the special characteristics appertaining to each.

Transitory cells.—These are, in general, fibre-cells; in other words, they are fusiform cells elongated in two opposite directions upon the same axis. They are far more frequently met with in hard than in soft cancer.

Fibres often enter into the formation of cancer: some resemble those of fibrous tumours; others are analogous to the fibres of cellular tissue (from the $\frac{1}{2000}$th to the $\frac{1}{800}$th of a line in diameter). In some cases they present the aspect of muscular fibres; in others, again, they resemble the so called *nucleated fibres* (fibres of elastic tissue).

The fibrous formations are wanting in the medullary variety of cancer.

4. *Blood vessels.*—These are found in the majority of cancerous tumours. Occasionally they are of recent formation, at other times they constitute the residue left after the destruction of organs, compressed and disintegrated by the cancerous growth. Cancerous tumours, containing a large number of recently formed vessels, constitute, in general, that variety to which the term *fungus hæmatodes* was formerly applied.

5. In cancerous tumours there is frequently found a thick fluid, containing a substance analogous to mucin or pyin. It coagulates into a colourless, striated, amorphous mass, on the addition of acetic acid, sulphate of iron, infusion of galls, alum, alcohol, and corrosive sublimate.

Such, then, are the constituents of cancer, and the mode in which they are grouped together explains the varieties of this disease met with in practice, as we shall now attempt to demonstrate, adopting, as before, the classification of Vogel.

FIRST VARIETY.—*Medullary Fungus or Encephaloid.*—In this variety of cancer, the cancer cells preponderate over the remaining histological elements of the morbid growth. Fibrous tissue is only met with in small quantity, and is sometimes entirely absent. A certain quantity of viscid fluid, as described above, is likewise found. When this fluid is very abundant, it may constitute a variety to which the term *gelatiniform* cancer has been sometimes applied. The blood vessels are not always obliterated; and, in fact, they are sometimes very numerous in this variety of cancer. When rupture of these vessels takes place and blood is effused, it constitutes that form of the disease to which the name of *fungus hæmatodes* has been given.

SECOND VARIETY.—*Schirrus.*—The fibrous tissue preponderates in this variety, and hence it is that schirrus is harder and firmer than encephaloid cancer. The blastema in which it is developed exists from the outset, and is sometimes met with alone, before any subsequent formation has taken place; for this reason, the microscope may not be able to detect fibres during the earlier stages of schirrous development. Vogel rather considers schirrus as a combination of non-malignant fibrous tumour with medullary cancer; inasmuch as that it occurs in a variety of forms, the extremes of which border, on the one hand, upon encephaloid, and on the other, upon fibrous tumours in general.

Cells are not entirely wanting in schirrus, but they are far more numerous in those cases where the cancerous disease approaches the medullary type. They are generally imperfectly developed, not very characteristic, and reveal themselves only by the presence of a greater or less number of nuclei. They are small, rounded, elliptical, and granular.

Elementary granules are likewise often met with, more especially when softening commences.

The viscid fluid is also found in this variety of cancer; it is sometimes sufficiently abundant to give a gelatinous character to the schirrous mass.

THIRD VARIETY.—*Melanosis in combination with Cancer; Melanotic Cancer.*—In the composition of this form of the disease, there enters a certain amount of black pigment. This pigment is sometimes free, at other times it is contained in cells which, in their external characters, differ but little, if at all, from real cancer cells (true melanosis). When free granules exist, they often consist of sulphuret of iron.

The combination of melanosis may occur with encephaloid as well as with hard cancer.

FOURTH VARIETY.—*Areolar or Alveolar, Gelatiniform Cancer or Colloid.*—When the gelatinous fluid found in cancer is greatly increased in quantity, the mass assumes a gelatinous consistence.

This form of cancer has for its stroma, fibres, which at one time form a delicate network, and at another, a thick, firm mass, of cartilaginous appearance, as in fibrous cancer. The interstices are filled up with a colourless, transparent jelly which, when examined under the microscope, presents the appearance of an amorphous mass. Sometimes, however, it contains cells of a very pale colour, which differ from ordinary cancer cells in being of larger size, and in the thinness of their walls. They occasionally, moreover, contain crystals of ammoniaco-magnesian phosphate.

Such is the microscopic history of cancer, according to Vogel. The author, however, does not appear to consider the cancer cell as a specific distinct type of cell.

This, however, has been done in France, and for it we are much indebted to the researches of M. Lebert. We shall endeavour, according to this author, to describe what the cancer cell really is, or, as he terms it, the *specific character of the cancer cell,* a character denied in England by Bennett, and in Germany by Virchow and Vogel.

The cancer cell is often incomplete, and in many tumours there may be seen large nuclei with nucleoli, and, in close proximity, smaller, less numerous, but perfect cells.

When the wall of the cell is perfect, its mean diameter is from $0^{mm.}$[*] .02 to $0^{mm.}$ .025. There is a special definite proportion between the dimension of the cell and that of the nucleus, which appears much larger than it really is, in comparison to the envelope which surrounds it. This alone, says M. Lebert, is sometimes sufficient to reveal the cancerous nature of the tissue examined.

The type of the cancer cell is a small regularly-shaped sphere, with an elliptical nucleus, excentrically placed, occupying nearly half or even more of the interior, and containing one more large nucleolus. This typical cell is rarely found in a perfect condition. The cellular envelope may assume an ovoid form,—elongated,—triangular, with blunt or sharp angles,—fusiform, pointed at either extremity, and large in the middle. On other occasions it presents, instead of two vertical appendages, one long and pointed prolongation emanating from a round cell; or three or four elongated and pointed appendages, emanating from an ovoid or irregular cell.

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[*] Millimètre, about the $\frac{1}{25}$th of an inch.

The outline of the cancer cell is pale and slightly marked, contrasting strongly with that of the nucleus, which is well defined. The contents of the cell, provided that no infiltration, whether pigmentary, fatty, or granular, exist, are composed of small molecules resembling the fibro-albuminous molecules met with in various other pathological productions. This fine granular appearance serves to throw into relief the external outline of the cell.

The pigmental infiltration of the cancer cell constitutes a special variety, viz., melanotic cancer. This is a primitive form, and not a degeneration of the cell.

There are two varieties of melanotic cancer.

In one, the black pigment is found external to the cells, between their interstices, in the form of fine granules, $0^{\text{mm.}}$ .002 in diameter; or in that of small globulins, of from $0^{\text{mm.}}$ .004 to $0^{\text{mm.}}$ .005; more rarely does it appear as true melanotic globules, $0^{\text{mm.}}$ .01 in diameter, without nuclei or nucleoli, and entirely filled with black pigment.

The second variety is far more common; it is that in which the pigment infiltrates the cancer cells under the form of granules or globules, which, at times, admit of our seeing the nucleus and nucleolus, and at others, fill the cell so completely as to obscure everything else. The cells which contain this pigment are, in general, somewhat distended and increased in size. According to M. Lebert, they may attain a diameter of from $0^{\text{mm.}}$ .03 to $0^{\text{mm.}}$ .04.

The nucleus is the invariable and characteristic element of the cancer cell. Sometimes the cellular envelope embraces it so closely, as to render it invisible even with a high power, and thus to lead to a belief in its absence.

When but imperfectly developed, this nucleus is round; when completely formed, it is ovoid or elliptical; the outlines being strongly marked. Varying in dimensions from $0^{\text{mm.}}$ .01 to $0^{\text{mm.}}$ .015, it rarely exceeds $0^{\text{mm.}}$ .02, or falls below $0^{\text{mm.}}$ .01 and $0^{\text{mm.}}$ .0075. When the nucleus is elliptical, it is generally from a quarter to a third longer in one direction than in the other.

The nucleus sometimes contains fine granules, but it more especially encloses a nucleolus, which has a dull appearance, and is much larger than in any other species of cell. Of these nucleoli there may be one, two, three, or even more. Their mean diameter varies from $0^{mm.}.0025$ to $0^{mm.}.0033$; occasionally they exceed these dimensions, and in such cases contain molecules, the nature of which has not as yet been ascertained, and upon which M. Lebert offers no opinion.

To sum up then, the typical cancer cell may be distinguished, in the great majority of cases, by certain fixed average dimensions, by the multiformity of its cellular walls, by its voluminous nucleus, and, lastly, by its large, dull, but very distinct nucleolus.

M. Lebert proceeds to describe two varieties of the cancer cell: the one is the mother cell; the other, the cell with concentric walls.

The mother cells are characterized by the multiplicity of their nuclei, which, while presenting their ordinary appearance, may be from three or four up to fifteen or twenty in number. The dimensions of these cells sometimes attain $0^{mm.}.04$ or $0^{mm.}.06$, and even more. In their interior are sometimes found smaller, but perfect, cells intermingled with the nuclei.

The concentric cancer cells are formed by superimposed layers. In some such cases, the perfect cell wall is surrounded by another cell wall, equally perfect but larger; in others, the concentric structure is produced by several superimposed membranous envelopes, of lamellar appearance. This is especially met with in colloid cancer.

It might sometimes be thought, that the cancer cells do not always possess the characteristics assigned to them by M. Lebert. According to this observer, when such is the case, it is owing to the cells being imperfectly developed, without cellular walls, and containing only small nuclei, with rarely a characteristic nucleolus.

Cancer cells are liable to numerous changes, according to M. Lebert; these are as follows:

a. Diffluence;

b. Thickening of their parietes;
c. Diffusion;
d. Granular or fatty infiltration;
e. Atrophy, with distortion of the cells and nuclei.

Diffluence.—In this case the cells lose their primitive configuration, and become a shapeless mass of molecular granules. This phenomenon may occur in three different degrees, according to M. Lebert.

In the first, the contents of the nucleus, viz., the nucleoli and molecular granules, are united to form a species of regular or irregular globe in the centre of the nucleus.

In the second, the nucleus itself loses its outline, and is replaced by a granular mass which retains its nuclear form, but is still very indefinite.

In the third, the entire cell is but a mass of granules, with or without regular outlines.

Thickening of the Cellular Parietes.—This is not an uncommon change; the cell wall may obtain a thickness of $0^{\text{mm.}}.005$. The wall in such a case presents a double outline, between which we may detect, at one time, a granular substance; at another, a dull homogeneous substance, and occasionally hyaline nuclei.

Diffusion.—This is a phenomenon of endosmosis, the cell being absorbed by a fluid having a lower specific gravity than the contents of the cell itself. The following results take place. The cell wall enlarges and becomes limpid; sometimes the imbibition actually takes place in this cell wall, and we then perceive two layers, separated by a transparent fluid; at other times the separation is only partial, and there appears on the surface of the cell, a prominence, in shape resembling a watch glass; in other cases, again, we see two or three of these partial elevations upon the periphery of the same cell wall, which, however, still retains its limpidity. It is probably to a similar phenomenon of imbibition, that the concentric cells owe the peculiar disposition of their walls.

Granular and Fatty Infiltration.—This is one of the most frequent of the modifications which the cancer cell undergoes.

It consists in the development of granular molecules, which at length so completely fill the cell, as entirely to conceal the nucleus and nucleolus,—a mere globular mass of granules being all that can be seen under the microscope. At the same time there are almost always observed a certain number of droplets, together with fat globules of various sizes. Sometimes the nucleus, infiltrated with fat, appears to be merely a fat vesicle.

This modification of the cell is not, according to M. Lebert, a local curative tendency on the part of the disease, but a simple cellular deterioration.

Atrophy and Distortion of the Cancer Cells.—This phenomenon is the inverse of that which has been termed diffusion. It is occasionally observed in those cases of cancer, which, having diminished in size, become, as it were, partially dried up and withered. This change consists in the cell losing its regular outline, and presenting internally a rugged appearance.

In cancerous tumours, rich in cells, we frequently meet with very small globules, which are thus described by M. Lebert.

Their diameter is from $0^{\text{mm.}}.003$ to $0^{\text{mm.}}.004$. Their interior is homogeneous, and they resemble small nucleoli. Some, which are larger, vary in size from $0^{\text{mm.}}.004$ to $0^{\text{mm.}}.006$; their outlines are more marked, and their contents are paler in colour, some even contain one or two nucleoli; many of these globulins are surrounded with a pale cellular envelope, the dimensions of which vary from $0^{\text{mm.}}.006$ to $0^{\text{mm.}}.007$. Other nuclei present a more perfect type of formation, their outlines are well marked, and they contain one or two large nuclei. We may thus observe a transition between the globulins, incomplete nuclei, and small cells on the one hand; and between the most perfectly developed nuclei and cells on the other.

Such are the views of M. Lebert respecting the cancer cell. We would, however, observe, that his *specific cancer cell* appears to us susceptible of numerous modifications and of great alterations; and that some of the reproaches which he addresses to Vogel and Virchow are equally applicable to himself; in other words, amid these modifications and varieties, etc., the typical cancer cell is, in all probability, an exceptional phenomenon.

As regards the remaining histological elements of cancer, M. Lebert differs but little from M. Vogel. He admits: 1. Fibrous tissue; 2. Fibro-plastic elements, which are sometimes met with in the form of long spindle-shaped bodies, with narrow, flat, elliptical nuclei; 3. Fat; 4. Pigment; 5. Gelatinous matter; 6. Mineral particles; 7. Inflammatory products (pus globules); 8. Blood globules; and 9. Blood vessels.

We now come to the most recent representative of the German school, viz., M. Forster. This observer states, that all that has hitherto been laid down by M. Lebert, respecting the cancer cell and its specific character, must be rejected, having no existence. The following are his views upon the subject.

Cancer is a growth composed of permanent tissues (fibres and vessels) and transitory cells, disposed in such a manner as to occupy the areolæ formed by the fibro-vascular network or stroma. The intercellular substance furnishes the cancer fluid. The stroma is formed of fibrous tissue, itself composed of fibres, some of which are, as it were, twisted and tangled; while others are stiff, straight, and spindle-shaped; elastic fibres are also sometimes met with, but cancer possesses no special fibres.

It is these different kinds of fibres which, by interlacing, form the areolæ or cells of cancer.

The fluid of cancer is composed of serum and solid constituents: the serum contains albumen, fat, extractive matters, and salts; the principal solid elements are molecules, granules, nuclei, and cells.

These cells present the most varied forms and dimensions: they may be round, globular or flattened, oval and angular, and are occasionally furnished with several tail-like prolongations or appendages; they are, in general, finely granular, and their wall has but one single outline: their size varies from the 1.000th to the 3.000th of a millimetre; they contain one nucleus, but rarely more. These nuclei are of large size; they are of round or oval form, smooth or faintly granular, with one or two nucleoli. Aside of these nucleated cells, may often be seen free nuclei, analogous to those of the cells themselves;

occasionally these free nuclei are the only solid constituents of the fluid portion of cancer.

According to M. Forster, the molecules and granules are of a similar nature to those met with in every blastema during the process of organization. The development of the cancer cells, their chemical reaction, and ultimate transformations, present, he asserts, the same phenomena as cells in general.

Is the so-called cancer cell a special formation peculiar to cancer? Such is the question put by M. Forster, and he hesitates not to assert, that the results afforded by the microscope are such as entirely to overthrow the opinion respecting the specific nature of these cells.

M. Forster states that they are met with of the same forms and dimensions, as often in healthy as in diseased tissues.

The transformation of the cancer cell, he asserts, offers no especial peculiarity.

These quotations are sufficient to shew the views entertained by M. Forster.

In the midst, then, of such a diversity of opinion, whose authority are we to admit?

Vogel, it is true, describes a species of cancer cell, but it is not characteristic; it may be met with in other cases; in a word, it is not peculiar to cancer. It appears, moreover, that since the publication of his work on *Pathological Anatomy*, he has adopted an opposite view, and completely denies the specific nature of the cancer cell. M. Forster, however, uses less circumlocution than Vogel: he asserts, that the cancer cell possesses no other characters than such as have been assigned to the cells of other tissues, even when normal. On the other hand, MM. Lebert, Robin, and the French microscopists, admit the specific nature of the cancer cell; they find it amid numerous varieties of cells, and in spite of the greatest modifications, although it may occasionally seem to have disappeared. What side, we again ask, are we to take amid such divergence of opinion? We might, indeed, content ourselves with being the mere historian of facts, and, as such, our task would be an easy one; we prefer, however, to act differently, believing that, in the present state of science, we may be permitted to form a decided opinion. Basing, therefore, our views upon the firm convictions of M. Robin, whom we regard as a great authority in microscopic pathology, we say: That if the German microscopists do not admit the existence of a specific cancer cell, it is simply because they have not detected it; and if so, it is because they have not employed sufficiently high powers. We shall quote, however, the following passage from the work of the above-mentioned observer:

" With such low powers, all the elements of the morbid " growth resemble one another; they are mere granulations: " tubercular corpuscles, detritus, isolated nuclei, misshapen epi- " thelial cells, all assume the same aspect, all are confounded " under the form of granulations of different sizes. But with " higher powers, we are enabled to detect, in succession, the " differences of size and shape, the absence or presence of a " nucleus, differences in the molecular granulations which the " cell contains, in their size, colour, agglomeration, or isolation, " etc., characteristics, indeed, which are not easily appreciable " by the reader, but which may readily be distinguished by an " observer.

" Far from being astonished at hearing certain pathologists " and microscopists assert that there are no special charac- " teristic elements in cancer, tubercle, etc., or that these said " elements cannot be distinguished from epithelial or other " cells, we regard the opinion thus expressed, as a natural " consequence of the imperfect notions afforded by their in- " struments.

" To this must undoubtedly be added, incomplete views " respecting the extent to which healthy anatomical elements, " such as epithelium, fibro-plastic tissues, etc., may vary, with- " out, however, losing their specific characters.

" This prejudice, promulgated by certain opticians, and re- " peated by many individuals who have never used a micro- " scope, is, nevertheless, the cause of numerous errors which " still exist."

SECT. I.—Chemical Composition of Cancer.

The chemical composition of cancerous tissue, and the results hitherto afforded by analysis, present but little similarity.

The following comparative analysis of encephaloid and schirrus cancer is given by M. Foy:*

	Encephaloid.	Scirrhus.
Albumen	47.00	42.00
White fatty matter	7.50	5.00
Red matter	5.35	3.25
Osmazome	4.00	0.00
Fibrin	6.50	5.85
Water	8.00	5.00
Oxide of iron	1.35	1.65
Sub-phosphate of lime	6.30	16.60
Carbonate of soda	2.75	5.00
Ditto of lime	4.00	6.60
Ditto of magnesia	1.00	0.85
Muriate of potash	2.70	4.10
Ditto of soda	2.00	3.25
Tartrate of soda	0.35	0.85

Analysis of encephaloid matter, by M. Baudrimont.

Water	0.6500
Fibrin	0.3325
Red and white fat	0.0180
Gelatine	0.0012
Osmazome	0.0008
Loss	0.0035

Analysis of schirrus, by M. Collard de Martigny.

Water	0.8718
Albumen	0.1857
Gelatine	0.0108
Fat	0.0010
Loss	0.0014

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* *Archiv. Gén. de Med.*, t. xvii ; 1828.

Analysis of schirrus, by Hecht.

	Schirrus of the mamma.	Schirrus of the uterus.
Gelatine	0.2778	0.2144
Fibrin	0.2778	0.1428
Fat	0.1388	0.1428
Albumen	0.0278	...
Water and loss	0.2778	0.5000

Analysis of schirrus, by M. Lheritier.

	Schirrus of the mamma.	Schirrus of the uterus.	Schirrus of the dorsal region.
Water	29.75	21.15	24.80
Albumen	28.10	29.85	21.70
Fibrin	18.80	15.20	27.15
Gelatine	7.60	...	8.17
Fat	2.00	...	8.05
Phosphuretted fat	...	6.00	...
Oxide of iron	1.15	1.25	traces
Yellow colouring matter, resembling cholesterine	...	7.00	...
Saline matters	12.60	9.55	10.13
	100.00	100.00	100.00

Heyfelder (*surgical clinic of Erlangen*) has published a series of analyses of cancer, some of which were made by Bibra and others by Gorup. These we shall now quote, according to M. Lebert.

1. *Cancer of the lip, analyzed by Von Bibra:*

Proteiform substance	8.01
Soluble albumen	2.01
Gluten	4.39
Extractive matter	0.92
Fat	5.55
Water	79.13
	100.00

100 parts of ash, 5.33 per cent. of dried matters:

Chloride of sodium	8.32
Sulphate of soda	3.00
Phosphate of soda	58.02
Earthy phosphates, iron	30.66
	100.00

2. *Analysis of two cancerous tumours of the orbit, the one unmixed, the other containing much adipose tissue.* (*M. Bibra.*)

	Pure Encephaloid.	Encephaloid, combined with fatty tissue.
Proteiform substance	9.07	9.03
Soluble albumen	2.03	2.10
Gluten	2.44	1.83
Extractive matter	2.29	1.53
Fat	4.18	8.27
Water	77.99	79.24
	100.00	100.00

3. *Melanotic encephaloid cancer of the eye ball, analysis of, after incineration, by M. Bibra.* In 100 parts there were 20.6 of dried matters.

Phosphatic alkali	3.7
Chloride of sodium	48.9
Earthy phosphates	28.9
Iron	18.5
	100.00

4. *Cancerous tumour of the parotid gland, analysis of, by M. Gorup.* Long continued boiling afforded gelatine. 1000 parts contained:

Water	810.43
Fixed substances	189.57
	1000.00

These fixed substances were as follows:

Pyin, alkaline sulphate, or watery extract, with compounds of chlorine	49.07
Phosphuretted fat and alcoholic extract	26.51
Albuminoid matter	106.33
Fixed salts	7.66

5. *Encephaloid cancer of the parotid region.* (*Bibra.*)

Proteiform substance	8.16
Soluble albumen	1.45
Gluten, extractive matters	3.63
Fat	1.56
Water	83.50
	100.00

100 parts when incinerated afforded 5.74 of dried matters:

Chloride of sodium	2.01
Phosphate of soda	87.99
Phosphate of lime, traces of iron	10.00
	100.00

After death, cancerous tumours were found in the liver and mesenteric glands; one was likewise found at the bottom of the wound produced by the operation.

Analysis afforded the following results:

Proteiform substance	10.59
Soluble albumen	1.96
Extractive matters	1.52
Gluten	3.48
Fat	1.14
Water	81.31
	100.00

In 100 parts of ash, there were 1.79 of dried matters:

Phosphate of soda	55.4
Chloride of sodium	21.0
Phosphate of lime, with traces of magnesia and iron	23.6
	100.0

It is needless to quote additional analyses. We shall merely state, that the following tumours were submitted to a similar examination, viz., an encephaloid cancer of the parotid region, a cancer of the penis, and lastly, a cancer of the rectum.

We may, however, quote *in extenso*, an analysis of a cancer of the left side of the face, inasmuch as it was most carefully made by M. Gorup.

100 parts contained:

Water	81.1
Fixed substances	18.9

These latter were thus constituted:

Soluble albumen (pyin), extractive matters, etc.	4.9
Phosphuretted fat, alcoholic extract	2.6
Albuminoid substance	10.6
Insoluble salts, unaffected by heat	0.8
	18.9

To sum up then, we shall merely say, that these analyses, having been made by different observers, and upon different principles, can scarcely be of any use, inasmuch as their results are, so to speak, analogous to those afforded by the analysis of many other organic changes. But, moreover, many chemists have asserted, that some of these analyses are similar to those of muscular tissue.

The whole subject therefore requires renewed investigation; but it would be very desirable that all future chemical researches should be carried out according to one single exact procedure; and that, as in the case of pus, the respective ratio between the water and solid constituents should first be taken into consideration, the entire results afforded by analysis being then referred to 100 parts of solid matters. In this manner alone, and by operating upon a large number of specimens, can we hope to obtain results admitting of comparison.

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